

XII. 14 CFR PART 36 APPENDIX A-AIRCRAFT NOISE MEASUREMENT AND EVALUATION100. Appendix A-Aircraft Noise Measurement and Evaluation Under Section 36.101a. Explanation

Appendix A addresses measurement and evaluation of noise generated by subsonic transport category large airplanes and jet airplanes. Helicopter noise measurement regulations are covered in Appendix H, unless otherwise noted in Appendix H.

101. Section A36.1 Introduction102. Section A36.1.1

This appendix prescribes the conditions under which airplane noise certification tests must be conducted and states the measurement procedures that must be used to measure airplane noise during each test conducted on or after [insert effective date of final rule]. The procedures that must be used to determine the noise evaluation quantity designated as effective perceived noise level, EPNL, under §§ 36.101 and 36.803 are also stated.

103. Section A36.1.2

The instructions and procedures given are intended to ensure uniformity during compliance tests and to permit comparison between tests of various types of airplane conducted in various geographical locations.

104. Section A36.1.3

A complete list of symbols and units, the mathematical formulation of perceived noisiness, a procedure for determining atmospheric attenuation of sound, and detailed procedures for correcting noise levels from non-reference to reference conditions are included in sections A36.6 to A36.9 of this appendix.

a. Explanation

This section specifies Part 36 Appendix A as a document that contains FAA approved measurement and evaluation methods for airplane noise certification. Each airplane noise test conducted on or after (TBD), must comply with the requirements of Appendix A or approved equivalent procedures.

105. Section A36.2. Noise Certification Test and Measurement Conditions106. Section A36.2.1 General107. Section A36.2.1.1

This section prescribes the conditions under which noise certification must be conducted and the measurement procedures that must be used.

Note: Many noise certifications involve only minor changes to the airplane type design. The resultant changes in noise can often be established reliably without the necessity of resorting to a complete test as outlined in this appendix. For this reason the FAA permits the use of appropriate "equivalent procedures". There are also equivalent procedures that may be used in full certification tests, in the interest of reducing costs and providing reliable results. Guidance

material on the use of equivalent procedures in the noise certification of subsonic jet and propeller-driven large airplanes is provided in the current Advisory Circular for this part.

a. Explanation

This Section specifies FAA approved test and measurement conditions required for airplane noise certification.

b. Supplemental Information

- (1) Test Conditions: Appendix A of Part 36 specifies test site requirements, noise measurement procedures and data evaluation procedures for airplane noise certification testing of subsonic transport category and turbojet powered large airplanes and turbojet powered airplanes. The applicant may follow the Appendix A procedures or may propose equivalent procedures for FAA review and approval.
- (2) Flight Path Intercept: The “flight path intercept” test method has been approved as an equivalent procedure wherein the airplane does not start from a static position on the airport runway for each flyover and lateral noise measurement (or land after each approach noise measurement), but remains in flight throughout the test series. See Section 2.1.1 of the appended ICAO TM. Stabilized airplane configuration and power are maintained until it is determined that the measured noise level falls below PNLTM -10 dB. An A-weighted noise level is often used as a metric for determining this; 15 dB below the maximum A-weighted noise level is usually sufficient. The flight path intercept test method may be applied to all noise testing, including: flyover, lateral and approach noise measurements. This method saves valuable time when the atmospheric conditions are within the allowable “window” and the noise measuring equipment are calibrated and operable by eliminating the takeoff, landing and turn-around for each measurement. This procedure also provides wider flexibility in the choice of test sites. The target airplane attitude, engine power or thrust, altitude over the microphones, constant configuration, etc., should be the same using the flight path intercept test method as it would be if the test were conducted from a standing start on the runway. See Section 2.1.1 of the appended ICAO TM for guidance on the use of the flight path intercept procedure.
- (3) Equivalent Procedures: Equivalent procedures are discussed in Section 2 of the appended ICAO Technical Manual (TM). The procedure for obtaining FAA approval of an equivalent procedure by an applicant is discussed under section 36.101 of this AC. Equivalent procedures are also discussed in (TBD) Sections A36.5.3.1, A36.5.4.3, A36.9.1.2, and B36.7(a) of this AC.

c. Procedures

- (1) Applicant's Responsibility: An applicant must prepare a noise compliance demonstration plan that specifies a proposed certification process, including equivalencies. This plan is to be submitted to the appropriate ACO noise specialist allowing sufficient calendar time (usually 2 months prior to the scheduled test) to permit adequate FAA review and possible revisions prior to the start of any noise certification testing.
- (2) FAA's Responsibility: The FAA reviewing authority, whether the local ACO noise specialist, the designated project manager, the directorate NCS, or any other assigned person, should review the applicant's plan to ensure compliance with the requirements of Appendix A and to determine the acceptability of proposed equivalent procedures. The FAA should also prepare a Type Inspection Authorization (TIA) that references the applicants plan and prescribes any other testing or inspections that may be necessary to be conducted in order to ensure compliance with total FAA noise certification requirements. The applicant may assist FAA with the preparation of the TIA. The FAA should ensure that noise certification testing is conducted in accordance with the approved plan and TIA. See FAA Order 8110.4A, (reference 3.a) for additional information regarding TIA requirements.

108. Section A36.2.2 Test Environment

109. Section A36.2.2.1

Locations for measuring noise from an airplane in flight must be surrounded by relatively flat terrain having no excessive sound absorption characteristics such as might be caused by thick, matted, or tall grass, shrubs, or wooded areas. No obstructions that significantly influence the sound field from the airplane must exist within a conical space above the point on the ground vertically below the microphone, the cone being defined by an axis normal to the ground and by a half-angle 80° from this axis.

Note: Those people carrying out the measurements could themselves constitute such obstruction.

a. Explanation

This section specifies the requirements for airplane noise certification test site characteristics to help insure uniformity in the noise measurement process. It also describes the clear zone above and around the microphone station that will allow noise measurements without influence from obstructions.

b. Supplemental Information

- (1) Test Site Locations: It may be possible to satisfy Appendix A noise certification test site requirements at either airport or non-airport locations when the flight path intercept test method is used. Proposed noise certification test site locations must be reviewed and approved by the FAA. Some criteria that the applicant should consider in choosing a non-airport test site include: level terrain, reduced air traffic, reduced ambient noise, improved weather conditions (temperature, humidity and wind), improved microphone placement, availability of field surveys, improved locations for aircraft position monitoring, and improved pilot sight and handling.
- (2) Noise Measurement Points: For the flyover, lateral and approach noise measurement points, 50 foot diameter circles of mowed grass (not exceeding 3" in height) are acceptable.
- (3) Snow: Snow in the area surrounding the noise measurement points may provide excessive absorption of airplane sound reflected from the ground. FAA has approved noise measurements during winter conditions when snow within 50 feet of the noise measurement points has been removed. However, snow should not be piled at the 50-foot semicircle borders facing the line of flight.
- (4) Plowed Fields: FAA permits the area within 50 feet of the noise measurement points to be plowed. Earthen or sandy surfaces should be reasonably tamped down. Plowed furrows, silt, or soft powdered surfaces are unacceptable.
- (5) Obstructions: Obstructions in the vicinity of the noise measurement points such as buildings, walls, trees, vehicles, and test personnel (if close enough) may be unacceptable because of reflections that influence measured noise levels.

c. Procedures

- (1) FAA Responsibility: An applicant should identify the proposed test site characteristics in a proposed noise certification compliance demonstration plan. FAA is to review and approve all test sites, proposed facilities, and noise measurement sites prior to noise certification testing.

110. Section A36.2.2.2

The tests must be carried out under the following atmospheric conditions.

a. Explanation

This section specifies the atmospheric conditions that are acceptable for airplane noise certification testing.

b. Supplemental Information

- (1) Unacceptable Test Data: When testing is conducted outside the limits of atmospheric conditions specified in this section, valid adjustments from test to reference conditions may not be possible, and the data may not be acceptable.

c. Procedures

- (1) Applicant's Responsibility: The applicant is responsible for the following:
- Specifying test atmospheric condition limits, meteorological instruments, calibration procedures, and data adjustment procedures in a noise compliance demonstration plan. See Section 2.1.6 of the appended ICAO TM for more on atmospheric sound attenuation limits.
 - Instrumentation for the conduct of meteorological measurements.
 - Obtaining FAA approval for deletion of any noise measurements that were obtained outside the approved limits of atmospheric conditions.
- (2) FAA's Responsibility: The FAA ACO noise specialist is responsible for ensuring that the applicant understands the test limits for atmospheric conditions and conducts testing within those limits.

111. Section A36.2.2.2 (a)

No precipitation.

a. Explanation

This subsection prohibits noise certification testing during conditions of rain or other precipitation. Rain and other precipitation (including fog, drizzle, snow) can affect the instrumentation and sound propagation during noise measurements.

b. Supplemental Information

- (1) Effects of Moisture on Microphones: Most microphones that are used during noise certification testing are susceptible to moisture. Precipitation, including snow, drizzle and fog, or excessive humidity may induce electrical arcing of the microphone sensors, making measured noise data unacceptable. However, some prepolarized microphones are less susceptible to electrical arcing during high-moisture conditions (consult the equipment manufacturer's specifications). Special care should be taken to ensure that any windscreens exposed to precipitation be thoroughly dry, inside and out, before use. Foam windscreens can trap water; wet foam windscreens should be avoided.
- (2) Microphone Internal Heaters: When internal heaters are provided, microphones are less likely to be affected by moisture in wet, humid, cold, or freezing atmospheric conditions.

c. Procedures

- (1) Precautions: Special precautions should be taken by the applicant to protect microphones when a test shutdown is caused by wet, humid, or near freezing atmospheric conditions. Instrumentation should be thoroughly dry before testing is resumed, to prevent arcing.

112. Section A36.2.2.2(b)

Ambient air temperature not above 95°F (35°C) and not below 14°F (-10°C), and relative humidity not above 95% and not below 20% over the whole noise path between a point 33 ft (10 m) above the ground and the airplane.

Note: Care should be taken to ensure that the noise measuring, airplane flight path tracking and meteorological instrumentation are operated within their environmental limitations.

a. Explanation

This subsection prescribes the ranges of ambient air temperature and relative humidity that are permitted during noise certification measurements. For each noise measurement, atmospheric temperature and relative humidity should be determined over the whole noise path between a location in the vicinity of the noise measurement points (at 10 meters above the ground) and the airplane. See Section 6.4 of the appended ICAO TM.

b. Supplemental Information

- (1) Assumed Ground Atmospheric Conditions: The temperature and relative humidity near the earth's surface can be affected by numerous factors, including solar heating, surface winds, local heating or cooling, increased or decreased local humidity, etc. To avoid localized anomalous conditions that often occur near the ground, the surface meteorological measurements are to be made 10m above the surface.
- (2) Criteria for Measuring Atmospheric Conditions: Experience has shown that proper measurement of non-reference meteorological conditions, and the associated adjustment of noise data for those conditions, are crucial to obtaining accurate, consistent, and repeatable test results. Thus, meteorological observations of the temperature and relative humidity are required over the whole sound propagation path from the aircraft to the vicinity of the noise measurement points.
- (3) Regulatory Flexibility: Appendix A allows flexibility in choosing ambient temperature and relative humidity conditions for noise testing, while minimizing the effects that different test-to-reference adjustments might have on reference EPNL values.

c. Procedures

- (1) Atmospheric Measurements: Several methods have been approved for the measurement of atmospheric conditions from 10 m above the ground to the altitude of the test airplane. See Section 6.4.2 of the appended ICAO TM. Some applicants have used instrumented unmanned model airplanes and balloons. The most common method consists of a manned meteorological airplane flown in a spiral flight path in the vicinity of the noise measurement points to measure the dry bulb temperature and dew point along the sound propagation path.
- (2) Atmospheric Data Interpolation: Atmospheric data obtained within 30 minutes of each noise measurement are time interpolated to permit evaluation of the atmospheric conditions along the sound propagation path. The time of airplane flight over the centerline microphone, or the time of attaining PNLTM, can be used as the interpolation time for each noise measurement condition.
- (3) Applicant's Responsibility: The applicant is responsible for providing the required meteorological equipment that was approved in the noise compliance demonstration plan.

113. Section A36.2.2.2(c)

Relative humidity and ambient temperature over the whole noise path between a point 33 ft (10 m) above the ground and the airplane such that the sound attenuation in the one-third octave band centered on 8 kHz will not be more than 12 dB/100 m;

a. Explanation

This subsection specifies limits on the atmospheric attenuation of sound at any point between 10 m above ground level and the altitude of the test airplane. These limits are applicable to each noise measurement.

b. Supplemental Information

- (1) Temperature and Relative Humidity Limits: The sound attenuation limits of section A36.2.2.2(c) may be exceeded when the dew point and the dry bulb temperature used to obtain the relative humidity are measured with a device that is accurate to ± 0.5 degrees Celsius. When layered sections of the atmosphere are used to compute equivalent weighted sound attenuation in each one-third-octave band, the FAA will determine whether a sufficient number of layered sections have been used. Relative humidity must be between 20 and 95 percent, except where the noise source (peak Noy value at time of peak PNLT after adjustment to reference conditions) is dominated by frequencies ≤ 400 Hertz. In this case, the relative humidity lower limit may be extended to 15 percent, resulting in higher (but acceptable) 8 kilohertz absorption rates than those for the 20 percent limit. See section 2.1.6 of the appended ICAO TM.

114. Section A36.2.2.2(d)

If the atmospheric absorption coefficients vary over the PNLTM sound propagation path by more than ± 1.6 dB/1000ft (± 0.5 dB/100m) in the 3150Hz one-third octave band from the value of the absorption coefficient derived from the meteorological measurement obtained at 33 ft (10 m) above the surface, "layered" sections of the atmosphere must be used as described in section A36.2.2.3 to compute equivalent weighted sound attenuations in each one-third octave band; the FAA will determine whether a sufficient number of layered sections have been used. For each measurement, where multiple layering is not required, equivalent sound attenuations in each one-third octave band must be determined by averaging the atmospheric absorption coefficients for each such band at 33 ft (10 m) above ground level, and at the flight level of the airplane at the time of PNLTM, for each measurement;

a. Explanation

This subsection specifies the use of layered sections of the atmosphere to adjust one-third-octave band sound pressure levels to reference day conditions. When the 3,150 Hertz band sound attenuation coefficient varies for more than ± 0.5 dB / 100 m [± 1.6 dB / 1,000 ft] over the sound propagation path that corresponds to the time of maximum PNLT, multiple layering must be used. This improves the definition of the mean attenuation rate over the sound propagation path.

b. Supplemental Information

- (1) When the use of multiple layered sections is required, the method to be used in defining the depth of the layered sections is specified in Section A36.2.2.3 of this Advisory Circular.

c. Procedures

- (1) Examples demonstrating procedures for deriving atmospheric sound attenuation coefficients when multiple layered sections are required are provided in section A36.2.2.3.

- (2) **Example:** The following example demonstrates the procedure for deriving the sound attenuation coefficients when multiple layering is not required. During an approach noise certification flight test for a subsonic transport jet airplane, the following atmospheric measurements were recorded (interpolated from flight data and adjusted to PNLTM flyover time):

Height, 10m (33ft)	Temperature, °F	RH, %	$\alpha(3150)$, dB/1000 ft
33 ft	71.0	65.5	5.5
100 ft	70.5	66.0	5.5
200 ft	68.4	63.0	5.5
300 ft	68.8	60.0	5.6
400 ft	67.5	56.0	5.8
500 ft	65.0	54.0	6.0

Table 1: Example – Atmospheric Measurements

In this simplified example, the sound attenuation coefficient ($\alpha_{3,150}$) over the sound propagation path varies less than the regulatory limit of 1.6 dB/1000 feet and therefore does not require use of multiple layers. The sound attenuation coefficients for each one-third-octave band will be the average sound attenuation coefficient determined from the temperature and relative humidity data measured at 10 m above the ground surface and at the airplane height, for maximum PNLTM. Assuming an airplane test height of 400 feet, the average coefficient in the 3,150 Hertz band will be 5.7 dB/1,000 feet (i.e., the average of 5.5 and 5.8). The coefficients for the other one-third-octave bands are determined in a similar manner. These average coefficients are used to correct the measured data along the propagation path to the reference conditions for approach. The same general procedure would be used for determining sound attenuation coefficients for take-off.

115. Section A36.2.2.2(e)

Average wind velocity 10 meters above ground is not to exceed 12 knots and the crosswind velocity for the airplane is not to exceed 7 knots. The average wind velocity must be determined using a thirty-second averaging period spanning the 10 dB down time interval. Maximum wind velocity 10 meters above ground is not to exceed 15 knots and the crosswind velocity is not to exceed 10 knots during the 10 dB down time interval.

a. Explanation

This subsection specifies average and maximum wind velocity limits for noise certification testing.

b. Procedures

- (1) **Wind Limitations:** The wind velocity limits throughout each noise measurement (PNLTM -10 dB) taken at 10 m above the ground in the vicinity of the noise measurement points are as follows:

- Maximum wind velocity in any direction is not to exceed 15 knots
- Maximum crosswind velocity is not to exceed 10 knots
- Thirty-second moving average wind velocity in any direction is not to exceed 12 knots and
- Thirty-second moving average crosswind velocity is not to exceed 7 knots.

If at any time during a noise measurement these limits are exceeded, the measurement is to be declared invalid and will have to be repeated. The FAA ground observer and test witness should monitor these critical values. FAA has not approved any method for making data corrections for wind velocity or direction.

- (2) Wind Velocity Measurement: The average wind velocity should be determined on the basis of a 30 second moving average sample (updating at a minimum of 1 second intervals) throughout the 10 dB-down period. The maximum wind velocity should be determined on the basis of a 1 second sample throughout the 10 dB-down period. (See section A36.2.2.4 for more on wind measurement.)
- (3) Real-time Crosswind Measurements: An applicant must provide approved real-time crosswind component measurement and recording equipment. When the applicant uses wind measurement and recording equipment, such as chart records that simultaneously and independently measures and records wind speed and direction, it may not be practical to determine the real-time crosswind component for each test condition. If the applicant does not provide acceptable real-time crosswind component measurement and recording equipment, the 10- and 7-knot limitations specified under Wind Limitations, above, for crosswind maximum and average limits become the maximum wind limitations regardless of wind direction.

116. Section A36.2.2.2(f)

No anomalous meteorological or wind conditions that would significantly affect the measured noise levels when the noise is recorded at the measuring points specified by the FAA; and

a. Explanation

This subsection prohibits noise certification testing when anomalous wind conditions exist.

b. Supplemental Information

- (1) Anomalous Winds: Wind velocity values complying with Appendix A requirements at 10 m may not be sufficient to ensure that the wind velocities at the airplane flight altitude or along the sound propagation path are not excessive. Such conditions may exist as a steady head or tail wind or as wind from varying directions. Anomalous winds may affect the handling characteristics of an airplane during a noise measurement period (also see section B36.8 (g)). They also may affect the transmitted noise. Anomalous winds include not only gusty and turbulent winds, but also wind shear, strong vertical winds, and high crosswinds at the aircraft altitude and along the sound propagation path. It is difficult for the FAA to quantify the acceptability of winds aloft.
- (2) Winds Aloft Measurement: Modern Inertial Navigation Systems (INS) and Differential Global Positioning Systems (DGPS) can provide on-board aircraft data that can be used to quantify winds aloft. The measurement of winds aloft can further be processed to provide a permanent record of wind velocity and direction.
- (3) Effects of Wind on Airplane Control: The FAA permits a ± 20 percent tolerance in overhead test altitude and a $\pm 10^\circ$ lateral tolerance relative to the extended runway centerline. If the flight crew cannot fly within the pretest-approved flight path tolerance limits, or experiences major variations in airspeed (see section B36.8 (g)), or the airplane "crabs" significantly during the flight, adverse or anomalous wind conditions aloft are often the cause.

c. Procedures

- (1) Flight Path: The flight crew should observe when winds aloft cause difficulty in maintaining the flight path or airspeeds, or when rough air in general makes the flight unacceptable. When the flight crew determines those anomalous winds aloft are present, noise measurement should be terminated.

(2) Applicant's Responsibility: When proposing a test site an applicant should consider that certain geographical areas are more susceptible to anomalous wind conditions than others. The applicant should only conduct testing when approved to do so by the FAA.

117. Section A36.2.2.2 (g)

Meteorological measurements must be obtained within 30 minutes of each noise test measurement; meteorological data must be interpolated to actual times of each noise measurement.

a. Explanation

This subsection specifies a requirement for measuring of atmospheric conditions within 30 minutes of each noise measurement.

b. Supplemental Information

(1) Upper Atmospheric Condition Measurements: Atmospheric conditions affect sound propagation; therefore, within 30 minutes of any noise measurement, temperature and relative humidity measurements from 10 m above the ground surface to the airplane test altitude at time of PNLTM must be made using an approved method. These measurements must be obtained and validated throughout the test period to ensure acceptable meteorological data for the noise data evaluation process.

c. Procedures

- (1) Atmospheric Measurements: Applicants should consider the maximum altitude that will be attained within the next 60 minutes (or less) of testing to ensure that adequate upper atmospheric measurements are acquired. Interpolations for all noise measurements are made to airplane altitude at the time of PNLTM. To have sufficient meteorological data to perform the interpolation to the actual time of each noise measurement, the first meteorological measurement flight of the day should be made within 30 minutes before the first noise measurement; the last meteorological measurement flight of the day should be made within 30 minutes after the last noise measurement flight of the day.
- (2) Atmospheric Data Interpolation: The time of airplane flight over the centerline noise measurement point or the time of attaining PNLTM can be used as the interpolation time for each noise measurement.

118. Section A36.2.2.3

When a multiple layering calculation is required by section A36.2.2.2(d) the atmosphere between the airplane and 33 ft (10 m) above the ground must be divided into layers of equal depth. The depth of the layers must be set to not more than the depth of the narrowest layer across which the variation in the atmospheric absorption coefficient of the 3150 Hz one-third octave band is not greater than +/-1.6 dB/1000 ft (+/-0.5 dB/100m), with a minimum layer depth of 100 ft (30 m). This requirement must be met for the propagation path at PNLTM. The mean of the values of the atmospheric absorption coefficients at the top and bottom of each layer may be used to characterize the absorption properties of each layer.

a. Explanation

This section specifies criteria for defining the depth of layers and a method for determining the mean sound attenuation coefficients when a multiple layering calculation is required for compliance with subsection A36.2.2.2 (d).

b. Procedures

- (1) Example: The following example demonstrates the procedure for deriving sound attenuation coefficients when multiple layered sections are required. During an approach noise certification flight test for a subsonic transport jet airplane, the following atmospheric measurements were recorded (interpolated from flight data and adjusted to PNLTM flyover time):

Height, 10m (33ft)	Temperature, °F	RH, %	$\alpha(3150)$, dB/1000 ft
33 ft	40.0	20.0	17.8
100 ft	39.0	20.0	17.3
200 ft	38.4	20.0	17.0
300 ft	38.0	19.0	16.3
400 ft	37.6	18.0	15.3
500 ft	37.0	18.0	14.9

Table 2: Example – Atmospheric Measurements

In this example, the sound attenuation coefficient ($\alpha_{3,150}$) over the sound propagation path varies by more than the limit of 1.6 dB/1,000 feet, requiring use of multiple layered sections. The sound attenuation coefficients for any one-third octave band is obtained by averaging the sound attenuation coefficients determined for each layered section. The coefficients for the other one-third octave bands are determined in a similar manner. The example is based on use of equal layer depths of 100 feet from the surface to the overflight height, inclusive. The mean values of sound attenuation coefficients at the top and bottom of each layer are used to represent the mean sound path attenuation coefficients rate of each layer as follows:

Layer Height, ft	$\alpha(3,150)$, dB/1,000 ft
Ground to 100	17.6
100 to 200	17.2
200 to 300	16.7
300 to 400	15.8
400 to 500	15.1

Table 3: Example – Atmospheric Correction

The above sound attenuation coefficients for each layer would be applied in adjusting the measured one-third-octave band data (3,150 Hz) over the propagation path to reference conditions for approach. The coefficients for the other one-third-octave bands would be determined similarly. This simplified example demonstrates the procedure used when multiple layers are required for determining the sound attenuation coefficients used for data correction during approach testing. The procedures for determining sound attenuation coefficients during take-off testing would be the same, although airplane test heights would be greater and the effects of atmospheric attenuation could be more significant. See explanation, supplemental information, and procedures under section A36.7 and A36.9.3.2.1 of this Advisory Circular for information on determining and applying atmospheric absorption adjustments.

119. Section A36.2.2.4

The airport control tower or another facility must be approved by the FAA for use as the central location at which measurements of atmospheric parameters are representative of those conditions existing over the geographical area in which noise measurements are made.

a. Explanation

This section specifies the requirement for approval of the location at which meteorological measurements are obtained.

b. Supplemental Information

- (1) Meteorological Measurements: Wind velocity, wind direction, crosswind velocity component, ambient temperature, and ambient relative humidity must be determined throughout the test period by an approved method. These data should be measured at a height of 10 m in the vicinity of the noise measurement points.
- (2) Airport Instrumentation: Airport (or other facility) meteorological facilities (located within a 1 mile distance from the noise measurement points) maybe used for noise certification testing only if approved by FAA. Experience has indicated that there may be problems in approving these facilities because they normally do not include:

- (a) Recent and acceptable calibrations of meteorological instruments and recording equipment.
- (b) Real-time recording equipment that meets required FAA sampling rates. The sampling rate should be at least one sample per second for wind velocity and wind direction and at least one sample per 10 seconds for temperature, relative humidity, and barometric pressure.
- (c) Meteorological instrumentation with adequate accuracy and response. The instrumentation used should meet the following minimum measurement tolerances:

Wind Velocity: ± 1.1 knots (± 2.0 km/h) above 1.7 knots (3.2 km/h)

Wind Direction: ± 5 degrees

Temperature: ± 1.0 degree F (± 0.5 degree C)

Relative Humidity: ± 3 percent

Barometric Pressure: ± 104 psf (5 kPa).

In addition, the wind velocity and wind direction sensors must have a minimum operating threshold of 1.7 knots. The wind velocity and wind direction data should be passed through an averaging function (or averaging filter) with characteristics that will sufficiently smooth out the impulsive nature of intermittent wind gusts. A 30-second moving average is recommended. The temperature, humidity, and barometric pressure sensors should have a response time of no greater than 10 seconds.

- (d) Meteorological instrumentation at the required height of 10 m above the ground.

c. Procedures

- (1) Meteorological Measurements: Meteorological data are to be continuously measured and recorded at a height of 10 m above the ground in the vicinity of the noise measurement points throughout the 10 dB-down period.
- (2) Applicant's Responsibility: Applicants should include a description of proposed meteorological measurement equipment for noise certification testing in a noise compliance demonstration plan.

120. Section A36.2.3 Flight Path Measurementa. Explanation

This section specifies requirements for tracking the airplane position, synchronizing the airplane position with noise measurements, and ensuring that position and performance data are sufficient for adjustments of measured noise data to reference conditions.

121. Section A36.2.3.1

The airplane height and lateral position relative to the flight track must be determined by a method independent of normal flight instrumentation such as radar tracking, theodolite triangulation, or photographic scaling techniques, to be approved by the FAA.

a. Explanation

This section specifies a requirement that the airplane's position in space be determined by an FAA-approved method.

b. Supplemental Information

- (1) Time-Space Position Measurement: Time-space-position information (TSPI) is to be determined at each half-second throughout the sound-measuring period (within 10 dB of PNLT) by an FAA-approved method that is independent from systems installed aboard, and normally used to control, the airplane. During processing, measured TSPI data should be interpolated over time to the time of sound emission of each half-second record within the 10 dB-down period. The time associated with each half-second record is 0.75 seconds before the end of each 2-second averaging period. Although the simplified procedure requires adjustment of only the (PNLT) maximum record to the reference track, emission coordinates must be determined for each half-second record for use in background noise correction procedures and/or for determination of incidence-dependent free-field microphone and windscreen corrections.
- (2) Flight Path Deviations: The FAA permits a ± 20 percent tolerance in overhead test altitude and a $\pm 10^\circ$ lateral tolerance relative to the extended runway centerline. These tolerances permit the applicant to conduct testing during most wind conditions without the fear of re-testing due to off-target flight paths. In conjunction with the climb gradient and approach angle, these flight path deviation limitations define the takeoff and approach "flight path" through which the aircraft is to fly during and throughout the noise measurements (during 10 dB-down period). Because the airport or projected centerline is in view during approach flight conditions, pilots generally do not have problems achieving testing within the approved flight path. However, during flyover and lateral noise measurements, the extended centerline is not visible and it may be more difficult to conduct flight within the approved flight path, especially during conditions of anomalous winds aloft. Installed DGPS or other space positioning instrumentation aboard the aircraft may provide valuable pilot input during the takeoff and climbout conditions.
- (3) Airplane Position Measurement: The FAA has approved several methods for measurement of airplane position. Additional guidance is also provided in Section 6.5 of the appended ICAO TM. FAA has generally permitted any system that the applicant can use to accurately determine the airplane position relative to the extended centerline for each half-second throughout the 10 dB-down period noise measurement. Photographic scaling has been approved when the applicant can produce coordinated time sequencing airplane positions at three or more locations during the overflight. These can then be interpolated to identify the airplane position throughout the 10 dB-down period and can be used as evidence to show that the airplane was within the maximum lateral and height deviations during each half-second of the noise test. FAA has also approved video camera systems in addition to the photo scaling methods. FAA approval of airplane position measurement systems requires demonstrated accuracy and system documentation.
- (4) Independent Airplane Position Determination: FAA will approve only those airplane position and altitude indicating and recording systems that are independent from the direct airplane flight path indicating systems. This reservation does not prohibit use of real time flight guidance systems (CDI/GDI) on board the aircraft to assist the flight crew during noise certification tests. These systems such as microwave

space position systems, INS, Precision DMU and DGPS can provide guidance to the flight crew by providing the direct, real-time airplane position relative to the extended runway centerline. These same independent systems can be recorded to produce a time coordinated permanent record of each test.

122. Section A36.2.3.2

The airplane position along the flight path must be related to the noise recorded at the noise measurement locations by means of synchronizing signals over a distance sufficient to assure adequate data during the period that the noise is within 10 dB of the maximum value of PNLT.

a. Explanation

This section specifies a requirement that airplane position data be synchronized with the noise measurements.

b. Supplemental Information

- (1) Instrumentation Synchronization: FAA-approved airplane position and altitude indicating and recording systems are to be time synchronized with the noise measurement and recording systems and meteorological measurements. The time synchronization between noise measurements and airplane position should be precise. A common time base is to be used to synchronize noise, aircraft tracking, and meteorological measurements.
- (2) Equipment Approval: Some off-the-shelf TSPI equipment may require software enhancement to accommodate the specific installation. Each applicant must submit information to VNTSC about the software used. VNTSC will determine whether the software requires approval by the FAA. All TSPI equipment and software should be demonstrated and approved by the FAA to ensure the system's operational accuracy.
- (3) Methods of Time Synchronization: Special care must be taken to properly synchronize acoustic data recordings with aircraft time-space-position information (TSPI) data. Specific methods, presented in order of preference, include:
 - Continuous Time-Code Recording-This method uses a time-code signal, such as IRIG B, which is a modulated, audio-frequency signal used for encoding time-base data, developed by the Inter-Range Instrumentation Group (IRIG). In this method, the time-code signals from individual generators that have been synchronized to a common time-base are continuously recorded by both the noise data recorder(s) and by the TSPI system during measurement test runs. Synchronization of multiple generators can be performed physically (by interconnecting via cable) or by means of radio transmission. Implementations of transmission-based synchronization include:
 - Direct recording of a transmitted continuous time-code signal.
 - Recording of the time-code signal from a time-code generator which is being fed the continuous radio-transmitted time-code signal or that has been synchronized to a burst of transmitted time-code signal. (This method allows for high-quality continuous time-code recording when there are intermittent reception problems.)
 - Synchronization should be accomplished at the start of each measurement day and checked at the end of each measurement day to minimize the effects of generator time drift. Any such drift must be documented and accounted for in processing.
 - The use of Global Positioning System (GPS)-based instruments for acquisition of TSPI data is becoming commonplace. All GPS receivers are capable of providing the user with precise time-base information (broadcast from the GPS satellite system), eliminating the need for a separate time keeping device in the TSPI system. For noise data recording or for non-GPS-based-TSPI systems, dedicated IRIG B time-code generators are available that uses the GPS signal to constantly update

and maintain time synchronization. Use of such a universal broadcast time-base can greatly simplify the logistics of time synchronization between instrumentation systems. It should be noted that there are two available time-bases for GPS-based systems, GPS Time and Coordinated Universal Time (UTC), whose values differ by more than 10 seconds at any given instant. Although the GPS signal includes both time bases, not all GPS receivers give the user access to both, therefore, the user should exercised caution in receiver selection.

- Many data recorders provide separate annotation channels in addition to the normal data channels. These channels are often not suitable for recording a modulated time-code signal because of limitations on dynamic range or bandwidth. In such cases, a normal data channel of the recorder must be dedicated to recording the time-code signal.
- When continuous time-code recording is used, analysis of the recorded acoustic data can be initiated by playing the time-code channel output into a time-code reader and triggering the analyzer based on readout time.
- Recording of Single Time Marker - This method involves transmittal and recording of a radio "hack", or tone, usually used to indicate the "recorders on" or "overhead" condition. This method typically requires a dedicated channel on both the noise and the TSPI recording systems.

When such a system is used, analysis can be triggered manually by an operator listening for the hack, or by a detector circuit responding to the tone. When the operator wishes to start analysis at a time other than that of the time marker, a stopwatch or delay circuit can be used to delay triggering of the analyzer. When manual triggering is employed, the operator must use extreme care to perform the triggering as accurately as possible. Accuracy to within one-tenth of a second can be expected from a conscientious human operator.

- Measurement of Interval between Recorder Start and Overhead-This method of synchronization involves use of a stopwatch or elapsed-time indicator to measure the interval between start-up of the noise data recorder and aircraft position overhead of the centerline noise measurement point. This method can be employed successfully as long as (1) the operator exercises care in timing, (2) the determination of overhead is performed accurately, and 3) the start-up characteristics of the recorder (in both record and playback modes) are known and repeatable. Some recorders have variable startup times that cannot be predicted. Such recorders are not suitable for this method of synchronization.
- Setting of Instrumentation Internal Time-Stamp Clock-Many digital recorders maintain a continuous internal time-of-day function by encoding time data in the recorded data stream. This method uses a digital recorder's subcode time, synchronized to the time-base used for the TSPI data. Unfortunately, the time-setting function on many recorders does not provide for the necessary precision. The "second" digits cannot be made to "tick" in synchrony with an external clock. Such recorders are unsuitable for this method of synchronization. As with the continuous time-code recording method, synchronization by this method should be checked at the beginning and end of each measurement day, and any drift accounted for in processing.
- Regardless of the synchronization method used, all elements affecting time synchronization (such as analyzer start-up delay, head displacement between normal and annotation data channels on analog recorders, delays in automated triggering circuits) must be identified, quantified, and accounted for in analysis and processing. Whenever human response to a timing event is required, errors cannot be accurately predicted, and conscientious operation is required to minimize such errors. The use of automated methods is preferred. Other methods, or variants of the listed methods may be appropriate, but FAA must approve all methods and instrumentation used.
- 10 dB-down Period: This period is the portion of the airplane flyover in which the measured noise level is within 10 dB of PNLTM (i.e., the period to be used for the calculation of EPNL). Care should

be taken during use of the flight path intercept method so that noise levels are outside the 10 dB-down period before flight path go-around procedures are initiated.

123. Section A36.2.3.3

Position and performance data required to make the adjustments referred to in section A36.9 of this appendix must be automatically recorded at an approved sampling rate. Measuring equipment must be approved by the FAA.

a. Explanation

This section specifies requirements for measuring sufficient airplane position and performance data to permit adjustments from test to reference conditions. See Section 6.6 of the appended ICAO TM. These data must be measured and recorded in permanent form, and the instrumentation used to record data must be FAA approved.

b. Supplemental Information

- (1) Configuration Records: Noise certification tests may be conducted with different combinations of gross weight, airspeed, flap settings, engine power settings, operable systems, etc. Combinations of these parameters are optimized for different missions (range, payload, speed, weather, runway length, etc.). Each combination of parameters is called a configuration. All aspects of the airplane configuration used during the noise certification testing must be permanently recorded to allow for adequate adjustment of the measured noise data from test conditions to reference conditions.
- (2) Recorder Sampling Rate: The measurements of airplane position, airplane airspeed, airplane performance and engine performance parameters are to be recorded at an approved sampling rate sufficient to permit adjustments from test to reference conditions throughout the 10 dB-down period. An acceptable recording sampling rate for transport category airplanes is two to five samples per second.
- (3) Airplane and Engine Performance: Examples of parameters needed for measurement of airplane and engine performance include: airplane altitude, climb angle, airspeed and gross weight, flap position, landing gear position, engine power setting parameters (e.g., compressor rotor speed, engine pressure ratio, exhaust gas temperature), and airplane accessory condition (e.g., A/C and APU "on" or "off"). Any other parameters that may affect measurement or adjustment of noise data and/or airplane or engine performance should also be recorded throughout the 10 dB-down period (e.g., SBV position, CG position).

c. Procedures

- (1) Applicant's Responsibility: Aircraft performance parameters to be recorded and their range and tolerance should be proposed by an applicant in a noise compliance demonstration plan and included in the FAA TIA.
- (2) Airplane Performance Instrumentation: Adequate airplane and engine parameters are to be recorded during all certification testing to ensure that airplane performance can be accurately determined. For example, for transport airplanes this may necessitate measurement and recording of airplane flap position, landing gear position, speed brake position, APU operation, and normal engine power setting and associated airplane flight parameters. Determination and recording of adequate information enables validation of the test airplane configuration and correction of airplane performance and engine performance from test day to reference day conditions.
- (3) NPD Correction Procedures: Section 2.1.2 of the appended ICAO TM provides an explanation of the NPD equivalency. The applicant may normalize the noise test data to an arbitrary generalized data reference

that may be different from the final reference airplane conditions. This procedure facilitates development of an NPD database that can provide certification compliance data for multiple airplane model derivatives. Noise measurements must be made at a sufficient number of engine power settings to adequately define the shape of the NPD curves. After FAA-approval of the generalized database, the NPD data may be adjusted to reference airplane conditions to determine certification EPNL values. The power-correlating parameters for NPD curves should either be corrected net thrust or corrected low-pressure rotor speed, as appropriate for the engine type.

124. Section A36.3 Measurement of Aircraft Noise Received on the Ground

a. Explanation

This section specifies the general requirements for airplane noise certification measurements.

b. Supplemental Information

- (1) Recordings: The time-varying waveform produced by the microphone response to noise signals during certification tests must be recorded. If there are questions about the data observed during the tests, the recording can be replayed, multiple times if necessary, to verify the results. Recorded data, whether digital or analog in nature, must allow reproduction and reprocessing of an analog signal over the frequency range of 40 Hz to 12.6 kHz. A dynamic range of at least 60 dB is recommended.

Note: Although the one-third-octave bands of interest are those with nominal center frequencies of 50 Hz through 10 kHz, to ensure that the entire actual bandwidth of the uppermost and lowermost bands is included, the center frequencies of the one-third-octave bands immediately outside this range are specified.

- (2) Approval of Instrumentation: FAA approval must be obtained for equipment used for measurement, recording, and analysis of aircraft noise. Most of the currently available instrumentation that is appropriate for aircraft noise certification use has already been approved, but implementations of new technology and variants or upgrades of existing instruments may have to be evaluated by VNTSC before FAA-approval. Of special concern, for digital instrumentation is the potential for an instrument's functionality to change as a result of firmware or operating system upgrades or modifications. Applicants should be aware that approval of a particular instrument might be version-dependent.

c. Procedures

- (1) Validation of System Configuration: FAA Order 8110.4A (Reference 3.a) provides an FAA policy and procedure to promote uniform implementation of the noise certification requirements of Part 36. Each applicant must submit information to VNTSC about the measurement, recording, and analysis instrumentation and software used. VNTSC will determine if whether any listed components require evaluation for approval by FAA.
- (2) Changes in System Configuration: If an applicant makes changes to the approved instrumentation, VNTSC should be notified before aircraft noise certification testing, to determine whether additional evaluation and FAA approval are required.

125. Section A36.3.1 Definitions

For the purposes of this section the following definitions apply:

126. Section A36.3.1.1

Measurement system means the combination of instruments used for the measurement of sound pressure levels, including a sound calibrator, windscreen, microphone system, signal recording and conditioning devices, and one-third octave band analysis system.

Note. - Practical installations may include a number of microphone systems, the outputs from which are recorded simultaneously by a multi-channel recording/analysis device via signal conditioners, as appropriate. For the purpose of this section, each complete measurement channel is considered to be a measurement system to which the requirements apply accordingly.

127. Section A36.3.1.2

Microphone system means the components of the measurement system which produce an electrical output signal in response to a sound pressure input signal, and which generally include a microphone, a preamplifier, extension cables, and other devices as necessary.

128. Section A36.3.1.3

Sound incidence angle means in degrees, an angle between the principal axis of the microphone, as defined in IEC 61094-3 and IEC 61094-4, as amended and a line from the sound source to the center of the diaphragm of the microphone.

Note. - When the sound incidence angle is 0°, the sound is said to be received at the microphone at "normal (perpendicular) incidence"; when the sound incidence angle is 90°, the sound is said to be received at "grazing incidence".

129. Section A36.3.1.4

Reference direction means, in degrees, the direction of sound incidence specified by the manufacturer of the microphone, relative to a sound incidence angle of 0°, for which the free-field sensitivity level of the microphone system is within specified tolerance limits.

130. Section A36.3.1.5

Free-field sensitivity of a microphone system means, in volts per Pascal, for a sinusoidal plane progressive sound wave of specified frequency, at a specified sound incidence angle, the quotient of the root mean square voltage at the output of a microphone system and the root mean square sound pressure that would exist at the position of the microphone in its absence.

131. Section A36.3.1.6

Free-field sensitivity level of a microphone system means, in decibels, twenty times the logarithm to the base ten of the ratio of the free-field sensitivity of a microphone system and the reference sensitivity of one volt per Pascal.

Note. - The free-field sensitivity level of a microphone system may be determined by subtracting the sound pressure level (in decibels re 20 µPa) of the sound incident on the microphone from the voltage level (in decibels re 1 V) at the output of the microphone system, and adding 93.98 dB to the result.

132. Section A36.3.1.7

Time-average band sound pressure level means in decibels, ten times the logarithm to the base ten, of the ratio of the time mean square of the instantaneous sound pressure during a stated time

interval and in a specified one-third octave band, to the square of the reference sound pressure of 20 μ Pa.

133. Section A36.3.1.8

Level range means, in decibels, an operating range determined by the setting of the controls that are provided in a measurement system for the recording and one-third octave band analysis of a sound pressure signal. The upper boundary associated with any particular level range must be rounded to the nearest decibel.

134. Section A36.3.1.9

Calibration sound pressure level means, in decibels, the sound pressure level produced, under reference environmental conditions, in the cavity of the coupler of the sound calibrator that is used to determine the overall acoustical sensitivity of a measurement system.

135. Section A36.3.1.10

Reference level range means, in decibels, the level range for determining the acoustical sensitivity of the measurement system and containing the calibration sound pressure level.

136. Section A36.3.1.11

Calibration check frequency means, in hertz, the nominal frequency of the sinusoidal sound pressure signal produced by the sound calibrator.

137. Section A36.3.1.12

Level difference means, in decibels, for any nominal one-third octave midband frequency, the output signal level measured on any level range minus the level of the corresponding electrical input signal.

138. Section A36.3.1.13

Reference level difference means, in decibels, for a stated frequency, the level difference measured on a level range for an electrical input signal corresponding to the calibration sound pressure level, adjusted as appropriate, for the level range.

139. Section A36.3.1.14

Level non-linearity means, in decibels, the level difference measured on any level range, at a stated one-third octave nominal midband frequency, minus the corresponding reference level difference, all input and output signals being relative to the same reference quantity.

140. Section A36.3.1.15

Linear operating range means, in decibels, for a stated level range and frequency, the range of levels of steady sinusoidal electrical signals applied to the input of the entire measurement system, exclusive of the microphone but including the microphone preamplifier and any other signal-conditioning elements that are considered to be part of the microphone system, extending from a lower to an upper boundary, over which the level non-linearity is within specified tolerance limits.

Note. - Microphone extension cables as configured in the field need not be included for the linear operating range determination.

141. Section A36.3.1.16

Windscreen insertion loss means, in decibels, at a stated nominal one-third octave midband frequency, and for a stated sound incidence angle on the inserted microphone, the indicated sound pressure level without the windscreen installed around the microphone minus the sound pressure level with the windscreen installed.

a. Explanation

This section specifies technical definitions of a total noise measurement system, its microphone system, and terms that relate to the acoustical performance characteristics of the measurement system and/or its components.

b. Supplemental Information

- (1) Applicability: These definitions may be applicable to measurement systems used in noise certification of other types of aircraft (e.g., small airplanes and rotorcraft).

c. Procedure

- (1) Applicant's Responsibility: An applicant's noise compliance demonstration plan should take these definitions into account in proposing measurement systems for use in noise certification.

142. Section A36.3.2 Reference Environmental Condition

143. Section A36.3.2.1

The reference environmental conditions for specifying the performance of a measurement system are:

- a) air temperature** 73.4°F (23°C);
- b) static air pressure** 101.325 kPa; and
- c) relative humidity** 50 %.

a. Explanation

This section specifies the required environmental conditions that serve as reference for defining the performance of the measurement systems used for noise certification.

b. Supplemental Information

These environmental specifications correspond to the recommended requirements of the International Electromechanical Commission (IEC).

144. Section A36.3.3 General

Note. - Measurements of aircraft noise that use instruments that conform to the specifications of this section yield one-third octave band sound pressure levels as a function of time. These one-third octave band levels are to be used for the calculation of effective perceived noise level as described in section A36.4.

145. Section A36.3.3.1

The measurement system must consist of equipment approved by the FAA and equivalent to the following:

- a) a windscreen (see A36.3.4);***
- b) a microphone system (see A36.3.5);***
- c) a recording and reproducing system to store the measured aircraft noise signals for subsequent analysis (see A36.3.6);***
- d) a one-third octave band analysis system (see A36.3.7); and***
calibration systems to maintain the acoustical sensitivity of the above systems within specified tolerance limits (see A36.3.8).

146. Section A36.3.3.2

For any component of the measurement system that converts an analog signal to digital form, such conversion must be performed so that the levels of any possible aliases or artifacts of the digitization process will be less than the upper boundary of the linear operating range by at least 50 dB at any frequency less than 12.5 kHz. The sampling rate must be at least 28 kHz. An anti-aliasing filter must be included before the digitization process.

a. Explanation

This section specifies the types of equipment required for a noise certification measurement system.

b. Supplemental Information

- (1) Recording and Analysis Equipment: The specifications for a measurement system allow flexibility in applicant equipment procurement. While on-site EPNL analysis may be useful for estimation of recording levels or for other diagnostic purposes, a true acoustical analysis requires that data be recorded in the field. This will allow for later reanalysis or auditing of acoustic data. A recording also facilitates later off-line processing of acoustic data, including application of adjustments for items such as system frequency response, microphone pressure response, and analyzer bandwidth error. Recording simplifies synchronization with other pertinent data, such as tracking and meteorological measurements. Such synchronization is necessary for proper application of many of the required adjustments to acoustic data, for elements such as microphone free-field response, windscreen incidence-dependent insertion loss, the influence of background noise, high altitude jet noise effects, non-reference flight performance, and non-reference meteorological conditions. Proper implementation of such adjustments in the field would be extremely difficult.

147. Section A36.3.4 Windscreen

148. Section A36.3.4.1

In the absence of wind and for sinusoidal sounds at grazing incidence, the insertion loss caused by the windscreen of a stated type installed around the microphone must not exceed ± 1.5 dB at nominal one-third octave midband frequencies from 50 Hz to 10 kHz inclusive.

a. Explanation

This section specifies the methodology for determining windscreen insertion loss and insertion loss tolerances for purposes of noise certification.

b. Supplemental Information

- (1) Determination of Data Adjustments for Windscreen Insertion Loss: The physical condition of a windscreen can significantly affect its performance, and manufacturer-provided data for windscreen insertion loss are valid only for new or clean, dry windscreens. Insertion loss data adjustments for windscreens may be obtained by free-field calibration in an anechoic chamber.

c. Procedure

- (1) Applicant's Responsibility: The applicant should specify proposed windscreen types and their insertion loss characteristics in a noise compliance demonstration plan.

149. Section A36.3.5 Microphone System150. Section A36.3.5.1

The microphone system must conform to the specifications in sections A36.3.5.2 to A36.3.5.4. Various microphone systems may be approved by the FAA on the basis of demonstrated equivalent overall electroacoustical performance. Where two or more microphone systems of the same type are used, demonstration that at least one system conforms to the specifications in full is sufficient to demonstrate conformance.

Note. - This demonstration of equivalent performance does not eliminate the need to calibrate and check each system as defined in section A36.3.9.

151. Section A36.3.5.2

The microphone must be mounted with the sensing element 4 ft (1.2 m) above the local ground surface and must be oriented for grazing incidence, i.e., with the sensing element substantially in the plane defined by the predicted reference flight path of the aircraft and the measuring station. The microphone mounting arrangement must minimize the interference of the supports with the sound to be measured. Figure A36-1 illustrates sound incidence angles on a microphone.

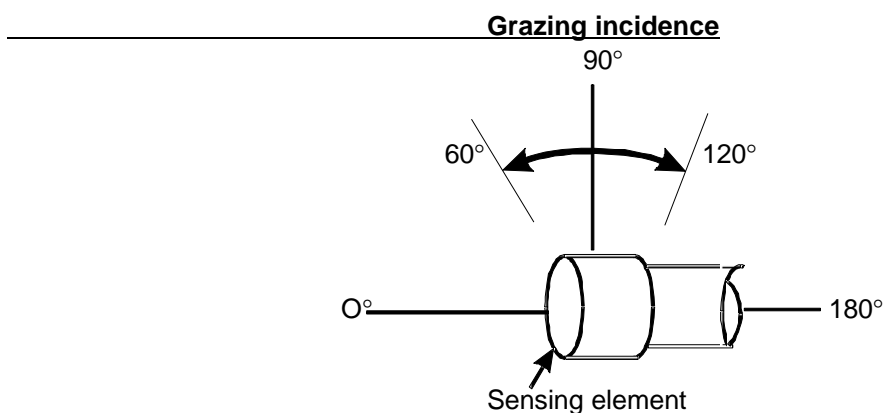


Figure A36-1: Illustration of Sound Incidence Angles on a Microphone

152. Section A36.3.5.3

The free-field sensitivity level of the microphone and preamplifier in the reference direction, at frequencies over at least the range of one-third-octave nominal midband frequencies from 50 Hz

to 5 kHz inclusive, must be within ± 1.0 dB of that at the calibration check frequency, and within ± 2.0 dB for nominal midband frequencies of 6.3 kHz, 8 kHz and 10 kHz.

153. Section A36.3.5.4

For sinusoidal sound waves at each one-third octave nominal midband frequency over the range from 50 Hz to 10 kHz inclusive, the free-field sensitivity levels of the microphone system at sound incidence angles of 30°, 60°, 90°, 120° and 150°, must not differ from the free-field sensitivity level at a sound incidence angle of 0° (“normal incidence”) by more than the values shown in Table A36-1. The free-field sensitivity level differences at sound incidence angles between any two adjacent sound incidence angles in Table A36-1 must not exceed the tolerance limit for the greater angle.

Nominal midband frequency kHz	Maximum difference between the free-field sensitivity level of a microphone system at normal incidence and the free-field sensitivity level at specified sound incidence angles				
	dB				
	Sound Incidence angle degrees				
	30	60	90	120	150
0.05 to 1.6	0.5	0.5	1.0	1.0	1.0
2.0	0.5	0.5	1.0	1.0	1.0
2.5	0.5	0.5	1.0	1.5	1.5
3.15	0.5	1.0	1.5	2.0	2.0
4.0	0.5	1.0	2.0	2.5	2.5
5.0	0.5	1.5	2.5	3.0	3.0
6.3	1.0	2.0	3.0	4.0	4.0
8.0	1.5	2.5	4.0	5.5	5.5
10.0	2.0	3.5	5.5	6.5	7.5

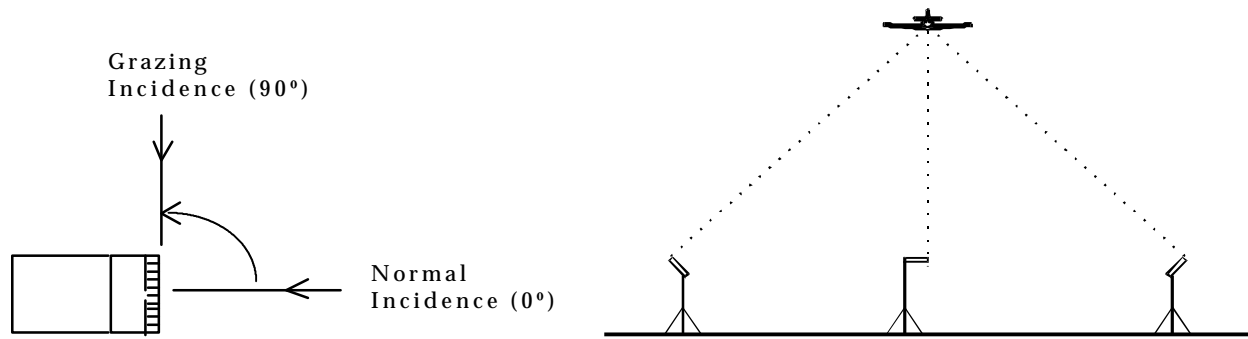
Table A36-1 Microphone Directional Response Requirements

a. Explanation

This section specifies the required performance characteristics of microphone systems that may be used during noise certification testing.

b. Supplemental Information

- (1) **Grazing Incidence:** The purpose of the grazing incidence specification is to minimize the effects of variations in the microphone response during measurement of airplane noise. By orienting the microphone so that the airplane is substantially within the plane of the microphone diaphragm (grazing incidence) during the 10 dB-down periods, all sound from the airplane impinges on the microphone at approximately the same angle relative to its axis.



- (2) Microphone Characteristics: These specifications are based on the performance characteristics of typical one-half-inch condenser microphones designed for nearly uniform frequency response at grazing incidence. Other microphones may be used, provided they meet the specified performance requirements. For example, prepolarized (electret condenser) free-field microphones exist that greatly minimize the possibility of arcing in humid environments and do not require an external polarization voltage. Although these microphones are intended primarily for use in normal-incidence free-field applications, they can be used in airplane noise certification testing if their performance at grazing incidence meets the requirements of section A36.3.5.
- (3) Microphone Specifications: Table A36.1 specifies the maximum permitted differences between the free-field sensitivity of a microphone at normal incidence and the free-field sensitivity at specified sound incidence angles for sinusoidal sound waves at each one-third-octave-band nominal midband frequency over the range of 50 Hz to 10 kHz. These differences are larger at higher frequencies, allowing for the effect of the microphone body in a free-field environment.

c. Procedures

- (1) Microphone Orientation: For microphones located directly under the flight path, an orientation angle of 90 degrees from vertical is appropriate regardless of target altitude. For lateral noise measurements, applicants may wish to reorient the microphones for grazing incidence for each target altitude in order to maintain substantially grazing-incidence throughout the 10 dB-down periods. In many cases, this reorientation can eliminate the need to apply data adjustments for varying-incidence, since the incidence angles will be more likely to be contained within ± 30 degrees of grazing incidence.
- (2) Applicant's Responsibility: The applicant should specify proposed microphone types and orientation for noise certification testing in a noise certification compliance demonstration plan.

154. Section A36.3.6 Recording and Reproducing Systems

155. Section A36.3.6.1

A recording and reproducing system, such as a digital or analog magnetic tape recorder, a computer-based system or other permanent data storage device, must be used to store sound pressure signals for subsequent analysis. The sound produced by the aircraft must be recorded in such a way that a record of the complete acoustical signal is retained. The recording and reproducing systems must conform to the specifications in sections A36.3.6.2 to A36.3.6.9 at the recording speeds and/or data sampling rates used for the noise certification tests. Conformance must be demonstrated for the frequency bandwidths and recording channels selected for the tests.

156. Section A36.3.6.2

The recording and reproducing systems must be calibrated as described in section A36.3.9.

a) For aircraft noise signals for which the high frequency spectral levels decrease rapidly with increasing frequency, appropriate pre-emphasis and complementary de-emphasis networks may be included in the measurement system. If pre-emphasis is included, over the range of nominal one-third octave midband frequencies from 800 Hz to 10 kHz inclusive, the electrical gain provided by the pre-emphasis network must not exceed 20 dB relative to the gain at 800 Hz.

157. Section A36.3.6.3

For steady sinusoidal electrical signals applied to the input of the entire measurement system including all parts of the microphone system except the microphone at a selected signal level within 5 dB of that corresponding to the calibration sound pressure level on the reference level range, the time-average signal level indicated by the readout device at any one-third octave nominal midband frequency from 50 Hz to 10 kHz inclusive must be within ± 1.5 dB of that at the calibration check frequency. The frequency response of a measurement system, which includes components that convert analog signals to digital form, must be within ± 0.3 dB of the response at 10 kHz over the frequency range from 10 kHz to 11.2 kHz.

Note. - Microphone extension cables as configured in the field need not be included for the frequency response determination. This allowance does not eliminate the requirement of including microphone extension cables when performing the pink noise recording in section A36.3.9.5.

158. Section A36.3.6.4

For analog tape recordings, the amplitude fluctuations of a 1 kHz sinusoidal signal recorded within 5 dB of the level corresponding to the calibration sound pressure level must not vary by more than ± 0.5 dB throughout any reel of the type of magnetic tape used. Conformance to this requirement must be demonstrated using a device that has time-averaging properties equivalent to those of the spectrum analyzer.

159. Section A36.3.6.5

For all appropriate level ranges and for steady sinusoidal electrical signals applied to the input of the measurement system, including all parts of the microphone system except the microphone, at one-third-octave nominal midband frequencies of 50 Hz, 1 kHz and 10 kHz, and the calibration check frequency, if it is not one of these frequencies, the level non-linearity must not exceed ± 0.5 dB for a linear operating range of at least 50 dB below the upper boundary of the level range.

Note 1. - Level linearity of measurement system components may be tested according to the methods described in IEC 61265 as amended.

Note 2. - Microphone extension cables configured in the field need not be included for the level linearity determination.

160. Section A36.3.6.6

On the reference level range, the level corresponding to the calibration sound pressure level must be at least 5 dB, but no more than 30 dB less than the upper boundary of the level range.

161. Section A36.3.6.7

The linear operating ranges on adjacent level ranges must overlap by at least 50 dB minus the change in attenuation introduced by a change in the level range controls.

Note. - It is possible for a measurement system to have level range controls that permit attenuation changes of either 10 dB or 1 dB, for example. With 10 dB steps, the minimum overlap required would be 40 dB, and with 1 dB steps the minimum overlap would be 49 dB.

162. Section A36.3.6.8

An overload indicator must be included in the recording and reproducing systems so that an overload indication will occur during an overload condition on any relevant level range.

163. Section A36.3.6.9

Attenuators included in the measurement system to permit range changes must operate in known intervals of decibel steps.

a. Explanation

This section specifies the performance characteristics required for a recording and reproducing system used to store airplane noise signals recorded during certification testing for subsequent analysis.

b. Supplemental Information

- (1) Recording: An applicant has a choice of recorder types that will satisfy the FAA requirement for recording "the complete acoustic signal" during certification testing. In addition to a magnetic tape recorder, other means of obtaining a "true" acoustic recording include digital audiotape (DAT), recordable compact disc (CD-R), and direct-to-hard-disk recording. The applicant should be aware that systems that use data compression techniques that result in substantial data loss, such as Mini-Disc ("MD") or digital compact cassette (DCC), are not acceptable.
- (2) Digital Recording Levels: The overload characteristic of a digital system is determined primarily by the limits of the analog-to-digital-conversion. Since such an overload condition is characterized by an abrupt, catastrophic type of distortion, the level range should be set so that the anticipated maximum signal level is at least 10 dB, and preferably 20 dB, below the upper boundary of the linear operating range.
- (3) Dynamic Range Limits-Digital Recorders: The lower limit of a digital recording system's usable dynamic range is more often determined by amplitude nonlinearity (due primarily to "quantization error") than by the presence of a noise floor. Digital devices (such as recorders or analyzers) that are to be used for aircraft noise certification purposes should be tested to determine the extent of such nonlinearity.
- (4) Consider a 16-Bit Quantization System: The theoretical dynamic range of such a system is usually assumed to be near 96 dB (i.e., $20 \cdot \log_{10}(2^{16})$). At the lower limit of this range, there is a potential for 6 dB error in the digitized signal versus the analog input signal that it represents. IEC 61265 imposes a ± 2.0 dB limit on acceptable linearity error outside of an instrument's linear operating range. As amplitude levels are increased above the lower quantization limit, the linearity error is reduced. If the guidance for setting the level range is followed, the usable dynamic range is further decreased. Significant improvement of amplitude linearity can be obtained by instrumentation designers via implementation of techniques such as oversampling and dithering. Therefore, testing should be performed to determine the actual limits for each digital instrument. Assumptions based on experience with analog instruments do not always apply.
- (5) Preemphasis Systems: Use of preemphasis will only be allowed if the system also employs complementary deemphasis. Attempts to compensate for the effects of a preemphasis filter by applying one-third-octave-band deemphasis adjustments (either numerically to analyzed data via a pink noise

correction or on a band-by-band basis using separate gain stages for each one-third-octave-band filter) are not allowed. In addition, use of a preemphasis / deemphasis system will require testing and documentation of all filters and gain stages involved to ensure that any errors are quantified and minimized, and that the system performs predictably and reliably.

- (6) Requirement for High-Frequency System Response, 10 kHz to 11.2 kHz: The purpose of this specification is to ensure that the entire passband of the 10 kHz one-third band is recorded properly. Many typical instrumentation DAT recorders feature a nominal 10 kHz bandwidth operating mode in which the antialiasing filter intrudes significantly within the 10 kHz one-third-octave passband. In such cases, the recorder must be operated in a nominal 20 kHz-bandwidth mode, which may reduce the number of available channels or the duration of available time per tape.
- (7) Attenuator Specification: This requirement allows for the use of switchable voltage input range settings (now commonplace on instrumentation DAT recorders) as controllable attenuation steps for gain-setting purposes. In all cases, attenuators must have fixed repeatable steps. Any devices in the measurement system that use vernier or continuously-adjustable gain controls must also have some demonstrable means of being fixed, or locked at a specific setting to eliminate nontraceable gain errors.

164. Section A36.3.7 Analysis Systems

165. Section A36.3.7.1

The analysis system must conform to the specifications in sections A36.3.7.2 to A36.3.7.7 for the frequency bandwidths, channel configurations and gain settings used for analysis.

166. Section A36.3.7.2

The output of the analysis system must consist of one-third octave band sound pressure levels as a function of time, obtained by processing the noise signals (preferably recorded) through an analysis system with the following characteristics:

- a) A set of 24 one-third octave band filters, or their equivalent, having nominal midband frequencies from 50 Hz to 10 kHz inclusive;***
- b) Response and averaging properties in which, in principle, the output from any one-third octave filter band is squared, averaged and displayed or stored as time-averaged sound pressure levels;***
- c) The interval between successive sound pressure level samples must be 500 ms \pm 5 milliseconds(ms) for spectral analysis with or without slow time weighting, as defined in section A36.3.7.4;***
- d) For those analysis systems that do not process the sound pressure signals during the period of time required for readout and/or resetting of the analyzer, the loss of data must not exceed a duration of 5 ms; and***
- e) The analysis system must operate in real time from 50 Hz through at least 12 kHz inclusive. This requirement applies to all operating channels of a multi-channel spectral analysis system.***

167. Section A36.3.7.3

The minimum standard for the one-third octave band analysis system is the class 2 electrical performance requirements of IEC 61260 as amended, over the range of one-third octave nominal midband frequencies from 50 Hz through 10 kHz inclusive.

Note. - Tests of the one-third octave band analysis system may be made according to the methods described in IEC 61260 for relative attenuation, anti-aliasing filters, real time operation, level linearity, and filter integrated response (effective bandwidth).

168. Section A36.3.7.4

When slow time averaging is performed in the analyzer, the response of the one-third octave band analysis system to a sudden onset or interruption of a constant sinusoidal signal at the respective one-third octave nominal midband frequency, must be measured at sampling instants 0.5, 1, 1.5 and 2 seconds(s) after the onset and 0.5 and 1 s after interruption. The rising response must be -4 ± 1 dB at 0.5 s, -1.75 ± 0.75 dB at 1 s, -1 ± 0.5 dB at 1.5 s and -0.5 ± 0.5 dB at 2 s relative to the steady-state level. The falling response must be such that the sum of the output signal levels, relative to the initial steady-state level, and the corresponding rising response reading is -6.5 ± 1 dB, at both 0.5 and 1 s. At subsequent times the sum of the rising and falling responses must be -7.5 dB or less. This equates to an exponential averaging process (slow weighting) with a nominal 1 s time constant (i.e., 2 s averaging time).

169. Section A36.3.7.5

When the one-third octave band sound pressure levels are determined from the output of the analyzer without slow time weighting, slow time weighting must be simulated in the subsequent processing. Simulated slow weighted sound pressure levels can be obtained using a continuous exponential averaging process by the following equation:

$$L_s(i,k) = 10 \log [(0.60653)10^{0.1L_s[i,(k-1)]} + (0.39347)10^{0.1L(i,k)}]$$

where $L_s(i,k)$ is the simulated slow weighted sound pressure level and $L(i,k)$ is the as-measured 0.5 s time average sound pressure level determined from the output of the analyzer for the k -th instant of time and the i -th one-third octave band. For $k=1$, the slow weighted sound pressure $L_s[i,(k-1=0)]$ on the right hand side should be set to 0 dB. An approximation of the continuous exponential averaging is represented by the following equation for a four sample averaging process for $k \geq 4$:

$$L_s(i,k) = 10 \log [(0.13)10^{0.1L[i,(k-3)]} + (0.21)10^{0.1L[i,(k-2)]} + (0.27)10^{0.1L[i,(k-1)]} + (0.39)10^{0.1L(i,k)}]$$

where $L_s(i,k)$ is the simulated slow weighted sound pressure level and $L(i,k)$ is the as measured 0.5 s time average sound pressure level determined from the output of the analyzer for the k -th instant of time and the i -th one-third octave band.

The sum of the weighting factors is 1.0 in the two equations. Sound pressure levels calculated by means of either equation are valid for the sixth and subsequent 0.5 s data samples, or for times greater than 2.5 s after initiation of data analysis.

Note. – The coefficients in the two equations were calculated for use in determining equivalent slow weighted sound pressure levels from samples of 0.5 s time average sound pressure levels. The equations should not be used with data samples where the averaging time differs from 0.5 s.

170. Section A36.3.7.6

The instant in time by which a slow time weighted sound pressure level is characterized must be 0.75 s earlier than the actual readout time.

Note. – The definition of this instant in time is required to correlate the recorded noise with the aircraft position when the noise was emitted and takes into account the averaging period of the slow weighting. For each 0.5 second data record this instant in time may also be identified as 1.25 seconds after the start of the associated 2 second averaging period.

171. Section A36.3.7.7

The resolution of the sound pressure levels, both displayed and stored, must be 0.1 dB or finer.

a. Explanation

This section specifies the required performance characteristics of an analysis system for use in airplane noise certification.

b. Supplemental Information

- (1) Analyzer Specifications: IEC 61260 specifies the Class 2 electrical performance requirements of one-third-octave-band filters, including tolerances for the attenuation in the transition bands (skirts) adjacent to the one-third-octave passbands. Most one-third-octave-band analysis systems offer only hardwired filtering algorithms that emulate the response of a traditional third-order analysis filter having a maximally-flat pass-band. However, some analysis systems allow the selection of other filtering algorithms which might not provide equivalent performance. FAA policy requires an applicant to demonstrate the effects that newly designed filter response characteristics might have on noise certification EPNL values.
- (2) Determination of Bandwidth Error Corrections: The manufacturer can establish the exact center frequencies of one-third-octave-band filters using either Base 2 or Base 10 systems. While the use of either method results in frequencies close to the nominal center frequencies referred to in 14 CFR Part 36, it is important to note which system is used so that the bandwidth error adjustment can be properly determined. Use of test frequencies calculated by a different base-number system than that for which the analyzer was designed can result in erroneous values for these adjustments.
- (3) Externally Controlled Linear-Integrating Analyzers: In cases where a computer or other external device is used to control and/or communicate with an analyzer performing linear integration, extra care should be taken to ensure that the integration period requirements are met. Some analyzers from major manufacturers have required factory modification in order to provide an integration time within 5 milliseconds of the specified 500-millisecond integration period.

172. Section A36.3.8 Calibration Systems

173. Section A36.3.8.1

The acoustical sensitivity of the measurement system must be determined using a sound calibrator generating a known sound pressure level at a known frequency. The minimum standard for the sound calibrator is the class 1L requirements of IEC 60942 as amended.

174. Section A36.3.9 Calibration and Checking of System

175. Section A36.3.9.1

Calibration and checking of the measurement system and its constituent components must be carried out to the satisfaction of the FAA by the methods specified in sections A36.3.9.2 through A36.3.9.10. The calibration adjustments, including those for environmental effects on sound calibrator output level, must be reported to the FAA and applied to the measured one-third-octave sound pressure levels determined from the output of the analyzer. Data collected during an overload indication are invalid and may not be used. If the overload condition occurred during recording, the associated test data are invalid, whereas if the overload occurred during analysis, the analysis must be repeated with reduced sensitivity to eliminate the overload.

176. Section A36.3.9.2

The free-field frequency response of the microphone system may be determined by use of an electrostatic actuator in combination with manufacturer's data or by tests in an anechoic free-field facility. The correction for frequency response must be determined within 90 days of each test series. The correction for non-uniform frequency response of the microphone system must be reported to the FAA and applied to the measured one-third octave band sound pressure levels determined from the output of the analyzer.

177. Section A36.3.9.3

When the angles of incidence of sound emitted from the aircraft are within $\pm 30^\circ$ of grazing incidence at the microphone (see Figure A36-1), a single set of free-field corrections based on grazing incidence is considered sufficient for correction of directional response effects. For other cases, the angle of incidence for each 0.5 second sample must be determined and applied for the correction of incidence effects.

178. Section A36.3.9.4

For analog magnetic tape recorders, each reel of magnetic tape must carry at least 30 seconds of pink random or pseudo-random noise at its beginning and end. Data obtained from analogue tape-recorded signals will be accepted as reliable only if level differences in the 10 kHz one-third-octave-band are not more than 0.75 dB for the signals recorded at the beginning and end.

179. Section A36.3.9.5

The frequency response of the entire measurement system while deployed in the field during the test series, exclusive of the microphone, must be determined at a level within 5 dB of the level corresponding to the calibration sound pressure level on the level range used during the tests for each one-third octave nominal midband frequency from 50 Hz to 10 kHz inclusive, utilizing pink random or pseudo-random noise. The output of the noise generator must be determined by a method traceable to the U.S. National Institute of Standards and Technology or an equivalent national standards laboratory as determined by the FAA within six months of each test series. Any changes in the relative output from the previous calibration at each one-third octave band may not exceed 0.2 dB. The correction for frequency response must be reported to the FAA and applied to the measured one-third octave sound pressure levels determined from the output of the analyzer.

180. Section A36.3.9.6

The performance of switched attenuators in the equipment used during noise certification measurements and calibration must be checked within six months of each test series to ensure that the maximum error does not exceed 0.1 dB.

181. Section A36.3.9.7

The sound pressure level produced in the cavity of the coupler of the sound calibrator must be calculated for the test environmental conditions using the manufacturer's supplied information on the influence of atmospheric air pressure and temperature. This sound pressure level is used to establish the acoustical sensitivity of the measurement system. Within six months of each test series the output of the sound calibrator must be determined by a method traceable to the U.S. National Institute of Standards and Technology or an equivalent national standards laboratory as determined by the FAA. Changes in output from the previous calibration must not exceed 0.2 dB.

182. Section A36.3.9.8

Sufficient sound pressure level calibrations must be made during each test day to ensure that the acoustical sensitivity of the measurement system is known at the prevailing environmental conditions corresponding with each test series. The difference between the acoustical sensitivity levels recorded immediately before and immediately after each test series on each day may not exceed 0.5 dB. The 0.5 dB limit applies after any atmospheric pressure corrections have been determined for the calibrator output level. The arithmetic mean of the before and after measurements must be used to represent the acoustical sensitivity level of the measurement system for that test series. The calibration corrections must be reported to the FAA and applied to the measured one-third octave band sound pressure levels determined from the output of the analyzer.

183. Section A36.3.9.9

Each recording medium, such as a reel, cartridge, cassette, or diskette, must carry a sound pressure level calibration of at least 10 seconds duration at its beginning and end.

184. Section A36.3.9.10

The free-field insertion loss of the windscreen for each one-third octave nominal midband frequency from 50 Hz to 10 kHz inclusive must be determined with sinusoidal sound signals at the incidence angles determined to be applicable for correction of directional response effects per section A36.3.9.3. The interval between angles tested must not exceed 30 degrees. For a windscreen that is undamaged and uncontaminated, the insertion loss may be taken from manufacturer's data. Alternatively, within six months of each test series the insertion loss of the windscreen may be determined by a method traceable to the U.S. National Institute of Standards and Technology or an equivalent national standards laboratory as determined by the FAA. Changes in the insertion loss from the previous calibration at each one-third-octave frequency band must not exceed 0.4 dB. The correction for the free-field insertion loss of the windscreen must be reported to the FAA and applied to the measured one-third octave sound pressure levels determined from the output of the analyzer.

a. Explanation

This section specifies the performance requirements for calibration systems and the procedures for calibration of the noise measurement system used for airplane noise certification.

(b) Supplemental Information

- (1) Pink Noise: Pink noise contains equal energy in each octave band or fractional octave band (e.g., the octave from 100 Hz to 200 Hz contains the same amount of energy as the octave from 1 kHz to 2 kHz, although it is distributed over a frequency range 10 times narrower).
- (2) Note on Pink Noise Usage: Because of the dynamic nature of the pink noise signal, longer samples produce statistically better measurements. At a minimum, recorded pink noise signals must have durations of 30 seconds.
- (3) Acoustic Calibrator Output Adjustments: Acoustic calibrator outputs may need to be adjusted for ambient conditions (such as temperature and atmospheric pressure), coupler volume, etc. FAA policy requires that all such adjustments be applied in the data processing stage rather than by using an adjusted calibration value in the analyzer. In this way, a traceable record of all data correction can be maintained.

- (4) Calibration Traceability: All performance calibration analyses of calibration equipment must be traceable to the U.S. National Institute of Standards and Technology or an equivalent national standards laboratory as determined by the FAA..

c. Procedures

- (1) Measurement System Calibration Requirements (All Components of the Measurement System Except Microphones): FAA policy requires that all components of the measurement system, as configured in the field, must be tested using pink noise signals at several levels within 5 days before and 5 days after a noise test. This testing determines frequency and amplitude linearity of the entire system, excluding the microphone and windscreen. If multiple microphone systems are fed to a single recorder, the tests must be performed with the entire multichannel system configuration. Signal levels should include the standard recording level and levels at 10 dB increments below it, down to within 10 dB of the overall (unweighted) level of the instrumentation noise floor. As an alternative to testing with pink noise at multiple levels, a single test using pink noise may be performed within 10 dB of the standard recording level to test frequency response, combined with sinewave testing at 50 Hz, 1 kHz and 10 kHz. At the levels identified above, this determines amplitude linearity over the frequency range of interest.
- (2) Field Acoustical Calibrations: At the start and end of each measurement day, at the beginning of each physical recording (each tape reel, cartridge, cassette, disk, etc.), and at the end of the last physical recording, an acoustic calibration signal of known amplitude and frequency must be fed through the entire measurement system (including microphone) as deployed in the field, and recorded. All components of the system (excluding the windscreen) should be in place at this time, including cables, attenuators, gain and signal-conditioning amplifiers, filters (including preemphasis) and power supplies. During calibration, attenuators and gain stages should be set to prevent overload, and to maintain the calibration signal within 10 dB of the standard recording level. If any switchable filters are present in the system that could affect the calibration signal, calibrations should be performed both with and without these filters enabled. No components of the electrical system should be added, removed, or replaced without re-calibrating the entire system immediately before and after each change.

The 0.5 dB limit stated in section A36.3.9.8 requires that sufficient determinations be made of the entire system's acoustical sensitivity during each measurement day to ensure that the response of the equipment is known for each test. The equipment shall be considered satisfactory if (after the required calibrator corrections are applied) the recorded variation over the period immediately before and immediately after each test series, within a given day, is not more than 0.5dB.

- (3) Measurement Program Equipment Calibrations:
- Microphones and preamplifiers (also windscreens, if included in free-field calibration): Pressure-response or free-field calibration within the 90 days before the start of the measurement program.
 - One-Third-Octave-Band Analyzers: Within 6 months before the start of the measurement program.
 - Recorders, Amplifiers, Filters, etc.: Within 6 months before the start of the measurement program.
 - Calibration Equipment: Within 6 months before the start of the measurement program, traceable to NIST or an equivalent national standards laboratory as determined by the FAA.
- (4) Applications of Adjustments for Incidence: When using microphones whose frequency response is nearly flat at grazing incidence, and when the angles of incidence of sound emitted from the aircraft are within $\pm 30^\circ$ of grazing incidence, a single set of data adjustments for free-field response (and windscreen insertion loss), based on grazing incidence, is considered sufficient to account for incidence effects. When it is impractical to orient the microphone properly to maintain grazing incidence, provided that a continuous record of TPSI is available, free-field (and windscreen insertion-loss) incidence data adjustments can be applied to the noise data on a spectral-record-by-spectral-record basis. These adjustments are obtained by calculating the angle of incidence for each record, using the point of time

which characterizes the 2-second averaging period (per section A36.3.7.6), and determining the airplane's emission coordinates (and angle of incidence) for the sound measured at that time.

- (5) Determination of Windscreen Data Adjustments: The physical condition of a windscreen can significantly affect its performance, and manufacturer-provided windscreen data adjustments for insertion loss are only valid for new, or clean, dry windscreens. When the windscreen data adjustments provided by the manufacturer are presented in the form of curves, care should be taken to include the insertion loss throughout each one-third-octave band, rather than just at the nominal midband frequency. Windscreen insertion loss can vary substantially within the frequency range of a single band and should be averaged or faired to more accurately correct one-third-octave-band data for the presence of the windscreen. Windscreen data adjustments may also be obtained by free-field calibration in an anechoic chamber.

185. Section A36.3.9.11

Ambient noise, including both acoustical background and electrical noise of the measurement system, must be recorded for at least 10 seconds at the measurement points with the system gain set at the levels used for the aircraft noise measurements. Ambient noise must be representative of the acoustical background that exists during the flyover test run. The recorded aircraft noise data is acceptable only if the ambient noise levels, when analyzed in the same way, and quoted in PNL (see A36.4.1.3 (a)), are at least 20 dB below the maximum PNL of the aircraft.

a. Explanation

This section specifies procedures for ambient (background) noise measurements..

b. Supplemental Information

- (1) Background Noise: Background noise comprises two parts: predetection (such as site ambient noise and instrumentation noise), which contributes on an energy basis to the signal level being measured, and postdetection (better described as minimum valid levels).

Note: Traditionally, analyzer floor levels have been used as postdetection values, but another appropriate consideration is the determination of the lower limit of amplitude linearity for digital equipment.

c. Procedures

- (1) Since instrumentation noise floor levels can add energy, the ambient background, noise measurement described in section A36.3.9.11 must be made with all gain stages and attenuators set as they would be used during airplane noise certification measurements. If it is expected that multiple settings will be required during the measurements, background noise data should be collected at each of these settings. Whenever possible, background noise recordings should be made for at least 30 seconds each, and care should be taken to ensure that the ambient site noise is truly representative of that present during the airplane noise certification tests.
- (2) Mean Background Noise Assessments: At least 10 seconds, but preferably 30 seconds, of predetection background noise should be time-averaged to determine mean levels for each one-third octave band. The PNL value for this mean spectrum should then be calculated using the procedures defined in Section A36.4.2. The airplane noise level data should also be analyzed, and PNL values calculated for each spectral record. As a rule of thumb, the maximum PNL value for the airplane event should be at least 20 dB above the PNL of the mean background noise spectrum for the data to be considered acceptable.

186. Section A36.3.9.12

Aircraft sound pressure levels within the 10 dB-down points (see A36.4.5.1) must exceed the mean ambient noise levels determined in section A36.3.9.11 by at least 3 dB in each one-third octave band, or must be adjusted using a method approved by the FAA; one method is described in the current Advisory Circular for this part.

a. Explanation

This section quantifies the amount by which aircraft sound pressure levels must exceed the ambient noise levels for noise certification testing, and specifies the requirement for data adjustment in cases where this exceedance amount is not met.

b. Supplemental Information

- (1) Background Noise Adjustments: Adjustments for the effects of background noise on measured airplane sound pressure levels must be performed. Determination of masking must be accomplished before any frequency-dependent adjustments (such as for system frequency response or microphone free-field response). Appendix 3 of the appended ICAO TM presents a background noise adjustment method that represents the international recommended practice. FAA has developed procedures contained in Appendix 3 of this AC to provide the applicant with a more definitive methodology for accounting for the effects of background noise, including some procedural elements not in the TM Appendix 3. Based on discussions that have occurred with the FAA/JAA harmonization working group addressing transport airplane noise certification standards, it is expected that future work will be proposed under the ICAO Committee on Aviation Environmental Protection to revise the ICAO TM Appendix 3 background noise adjustment method.

187. Section A36.4 Calculation of Effective Perceived Noise Level from Measured Data188. Section A36.4.1 General189. Section A36.4.1.1

The basic element for noise certification criteria is the noise evaluation measure known as effective perceived noise level, EPNL, in units of EPNdB, which is a single number evaluator of the subjective effects of airplane noise on human beings. Simply stated, EPNL consists of instantaneous perceived noise level, PNL, corrected for spectral irregularities, and for duration. The spectral irregularity correction, called "tone correction factor", is made at each time increment for only the maximum tone.

190. Section A36.4.1.2

Three basic physical properties of sound pressure must be measured: level, frequency distribution, and time variation. To determine EPNL, the instantaneous sound pressure level in each of the 24 one-third octave bands is required for each 0.5 second increment of time during the airplane noise measurement.

191. Section A36.4.1.3

The calculation procedure that uses physical measurements of noise to derive the EPNL evaluation measure of subjective response consists of the following five steps:

- (a) ***The 24 one-third octave bands of sound pressure level are converted to perceived noisiness (noy) using one of the methods of sub-section A36.4.2.1(a). The noy values are combined and then converted to instantaneous perceived noise levels, PNL(k).***

(b) A tone correction factor $C(k)$ is calculated for each spectrum to account for the subjective response to the presence of spectral irregularities.

(c) The tone correction factor is added to the perceived noise level to obtain tone-corrected perceived noise levels $PNLT(k)$, at each one-half second increment:

$$PNLT(k) = PNL(k) + C(k)$$

The instantaneous values of tone-corrected perceived noise level are derived and the maximum value, $PNLTM$, is determined.

(d) A duration correction factor, D , is computed by integration under the curve of tone-corrected perceived noise level versus time.

(e) Effective perceived noise level, $EPNL$, is determined by the algebraic sum of the maximum tone-corrected perceived noise level and the duration correction factor:

$$EPNL = PNLTM + D$$

a. Explanation

This Section specifies that the noise rating for an individual airplane event for purposes of noise certification is Effective Perceived Noise Level (EPNL in units of EPNdB). It is based on the results of extensive psychoacoustical research conducted primarily in the 1950's and early 1960's concerning the subjective effects of airplane noise on human beings. EPNL is a single number measure of the noise of a single airplane flyover that approximates laboratory annoyance responses. It is derived from calculations of perceived noise level PNL (in units of PNdB) and adjusted for the presence of audible pure tones or discrete frequencies and for duration of the airplane flyover. The PNL metric accounts for variations in hearing sensitivity as a function of frequency, as does the A-Weighting factor. The PNL metric is more sophisticated than A-weighting in that it also accounts for changes in annoyance sensitivity as a function of amplitude (as amplitude increases human hearing sensitivity at higher and lower frequencies improves). The EPNL computation process effectively yields a time integrated annoyance level.

192. Section A36.4.2 Perceived Noise Level

193. Section A36.4.2.1

Instantaneous perceived noise levels, $PNL(k)$, must be calculated from instantaneous one-third octave band sound pressure levels, $SPL(i,k)$ as follows:

(a) Step 1: For each one-third octave band from 50 through 10,000 Hz, convert $SPL(i,k)$ to perceived noisiness $n(i,k)$, by using the mathematical formulation of the noy table given in section A36.4.7, or to the Table of Perceived Noisiness in the current Advisory Circular for this part.

(b) Step 2: Combine the perceived noisiness values, $n(i,k)$, determined in step 1 by using the following formula:

$$\begin{aligned} N(k) &= n(k) + 0.15 \left\{ \left[\sum_{i=1}^{24} n(i,k) \right] - n(k) \right\} \\ &= 0.85n(k) + 0.15 \sum_{i=1}^{24} n(i,k) \end{aligned}$$

where $n(k)$ is the largest of the 24 values of $n(i,k)$ and $N(k)$ is the total perceived noisiness.

(c) Step 3: Convert the total perceived noisiness, $N(k)$, determined in Step 2 into perceived noise level, $PNL(k)$, using the following formula:

$$\text{PNL}(k) = 40.0 + \frac{10}{\log 2} \log N(k)$$

Note: $\text{PNL}(k)$ is plotted in the current Advisory Circular for this part.

a. Explanation

This section specifies the method(s) used to calculate perceived noise level (PNL, in units of PNdB) for each one-third-octave-band spectral record, i.e., each $\frac{1}{2}$ second spectrum.

b. Supplemental Information

- (1) "Instantaneous" Levels: For the purposes of this procedure, "instantaneous levels" are considered to be one-third-octave-band sound pressure levels for each half-second record obtained using a continuous exponential averaging process as described in A36.3.7.4.

194. Section A36.4.3 Correction for Spectral Irregularities

195. Section A36.4.3.1

Noise having pronounced spectral irregularities (for example, the maximum discrete frequency components or tones) must be adjusted by the correction factor $C(k)$ calculated as follows:

a. Explanation

This section specifies a 10-step procedure for identifying the tonal content of each one-third-octave-band spectrum and for determining correction factors for those spectra that are used to increase PNL values (designated PNLT).

b. Procedures

- (1) Data Precision for Tone Correction Computation: Prior to Step 1, all one-third-octave-band sound pressure levels should be temporarily rounded to 0.1 dB resolution. The tone-correction procedure presented here includes several steps that utilize decibel level criteria to characterize the significance of tonal content. These criteria can become artificially sensitive to small variations in level if resolution finer than 0.1 dB is used in the computations.

(a) Step 1: After applying the corrections specified under section A36.3.9, start with the sound pressure level in the 80 Hz one-third octave band (band number 3), calculate the changes in sound pressure level (or "slopes") in the remainder of the one-third octave bands as follows:

$$s(3,k) = \text{no value}$$

$$s(4,k) = SPL(4,k) - SPL(3,k)$$

•
•

$$s(i,k) = SPL(i,k) - SPL(i-1,k)$$

•
•

$$s(24,k) = SPL(24,k) - SPL(23,k)$$

(b) Step 2: Encircle the value of the slope, $s(i, k)$, where the absolute value of the change in slope is greater than five; that is where:

$$|\Delta s(i, k)| = |s(i, k) - s(i-1, k)| > 5$$

(c) Step 3:

(1) If the encircled value of the slope $s(i, k)$ is positive and algebraically greater than the slope $s(i-1, k)$ encircle $SPL(i, k)$.

(2) If the encircled value of the slope $s(i, k)$ is zero or negative and the slope $s(i-1, k)$ is positive, encircle $SPL(i-1, k)$.

(3) For all other cases, no sound pressure level value is to be encircled.

a. Explanation

Steps 1-3 specify the method used to identify significant tones in spectral data.

(d) Step 4: Compute new adjusted sound pressure levels $SPL'(i, k)$ as follows:

(1) For non-encircled sound pressure levels, set the new sound pressure levels equal to the original sound pressure levels, $SPL'(i, k) = SPL(i, k)$.

(2) For encircled sound pressure levels in bands 1 through 23 inclusive, set the new sound pressure level equal to the arithmetic average of the preceding and following sound pressure levels as shown below:

$$SPL'(i, k) = \frac{1}{2} [SPL(i-1, k) + SPL(i+1, k)]$$

(3) If the sound pressure level in the highest frequency band ($i=24$) is encircled, set the new sound pressure level in that band equal to:

$$SPL'(24, k) = SPL(23, k) + s(23, k)$$

$$SPL'(24, k) = SPL(23, k) + s(23, k)$$

(e) Step 5: Recompute new slope $s'(i,k)$, including one for an imaginary 25th band, as follows:

$$s'(3,k) = s'(4,k)$$

$$s'(4,k) = SPL'(4,k) - SPL'(3,k)$$

•

•

$$s'(i,k) = SPL'(i,k) - SPL'(i-1,k)$$

•

•

$$s'(24,k) = SPL'(24,k) - SPL'(23,k)$$

$$s'(25,k) = s'(24,k)$$

(f) Step 6: For i , from 3 through 23, compute the arithmetic average of the three adjacent slopes as follows:

$$\bar{s}(i,k) = 1/3 [s'(i,k) + s'(i+1,k) + s'(i+2,k)]$$

(g) Step 7: Compute final one-third octave-band sound pressure levels, $SPL''(i,k)$, by beginning with band number 3 and proceeding to band number 24 as follows:

$$SPL''(3,k) = SPL(3,k)$$

$$SPL''(4,k) = SPL''(3,k) + \bar{s}(3,k)$$

•

•

$$SPL''(i,k) = SPL''(i-1,k) + \bar{s}(i-1,k)$$

•

•

$$SPL''(24,k) = SPL''(23,k) + \bar{s}(23,k)$$

a. Explanation

Steps 4 through 7 specify methods to smooth one-third-octave-band spectra to obtain pseudo-broadband levels that would have been present in the absence of tones.

b. Procedures

(1) Data Adjustments for Background Noise When the procedure presented in Appendix 3 of this Advisory Circular is used for correction for the effects of background noise, Steps 4 and 5 of this tone-correction procedure should be modified as follows: Step 4(c) - The “Last Unmasked Band” should be used in place of the highest-frequency band ($i=24$). Step 5 - A new slope, $s'(25,k)$, should be calculated for the band above the “Last Unmasked Band” as described for an imaginary 25-th band. This slope should be used in place of the slope derived from the actual level of the “Last Unmasked Band” +1. (See Supplementary Information under Section B.36.9.1.(b)(3) for information on background noise correction procedures.)

(h) Step 8: Calculate the differences, $F(i,k)$, between the original sound pressure level and the final background sound pressure level as follows:

$$F(i,k) = \text{SPL}(i,k) - \text{SPL}''(i,k)$$

and note only values equal to or greater than 1.5.

a. Explanation

Step 8 specifies a requirement to compare the differences between a derived sound pressure level and the original sound pressure level.

(i) Step 9: For each of the relevant one-third octave bands (3 through 24), determine tone correction factors from the sound pressure level differences $F(i,k)$ and Table A36-2.

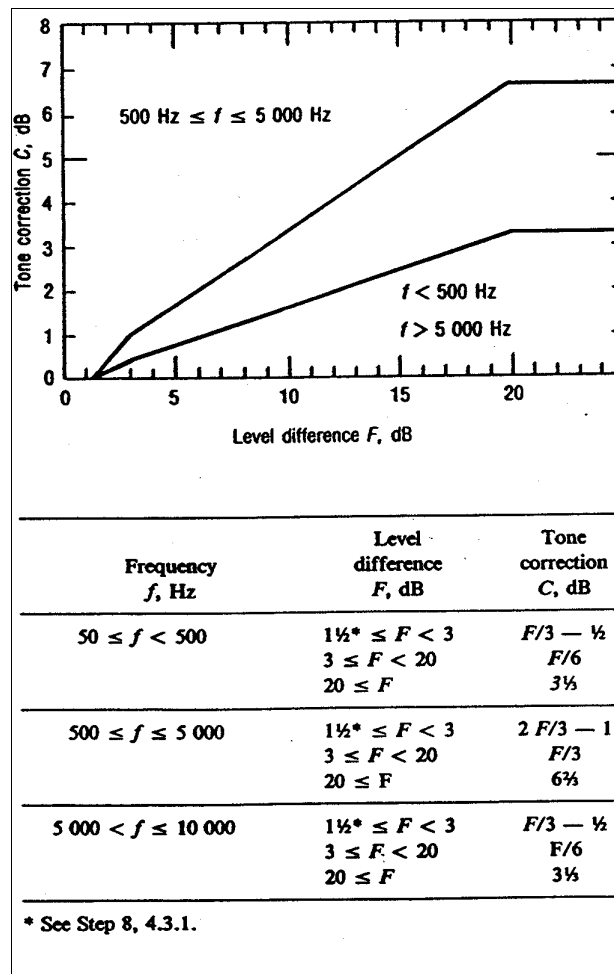


Table A36-2: Tone Correction Factor

a. Explanation

Step 9 specifies a method of determining tone correction factors for each tone.

(j) Step 10: Designate the largest of the tone correction factors, determined in Step 9, as $C(k)$. (An example of the tone correction procedure is given in the current Advisory Circular for this part.) Tone-corrected perceived noise levels $PNLT(k)$ must be determined by adding the $C(k)$ values to corresponding $PNL(k)$ values, that is:

$$PNLT(k) = PNL(k) + C(k)$$

For any i -th one-third octave band, at any k -th increment of time, for which the tone correction factor is suspected to result from something other than (or in addition to) an actual tone (or any spectral irregularity other than airplane noise), an additional analysis may be made using a filter with a bandwidth narrower than one-third of an octave. If the narrow band analysis corroborates these suspicions, then a revised value for the background sound pressure level $SPL''(i,k)$, may be determined from the narrow band analysis and used to compute a revised tone correction factor

for that particular one-third octave band. Other methods of rejecting spurious tone corrections may be approved.

a. Explanation

Step 10 specifies a method of obtaining the largest tone-correction factor associated with the resulting sound pressure level.

Note: The term “background” in this case, refers to the levels of broadband noise of the airplane, and not to the ambient or instrumentation background noise.

c. Procedures

- (1) Data Precision: At this point, the original resolution should be restored. Although the required precision of reported EPNL is only 0.1 dB, all other intermediate calculations external to the tone correction process should maintain a precision of at least 0.01 dB.
- (2) Identification of Pseudotones: Appendix 2 of the appended ICAO TM presents guidance material on methods for identifying pseudotones. Note that the use of ground plane or 10-meter microphones is supplemental to the required 4-foot (1.2-meter) microphones, and is allowed only for identification of frequency bands within which pseudotones occur, not for the determination of aircraft noise certification levels.
- (3) Tone Correction Factors when Pseudotones Are Present: When pseudotones are properly identified in the 800 Hz band or below, the associated tone-correction factors are not added to PNL values as described in Step 10. All other steps and computations must be performed for these bands.
- (4) Tone Correction Factor Adjustment: When tone-correction factors result from false or fictitious tones, recalculation is allowed using revised sound pressure level values (based on narrow-band analysis) of the smoothed spectral levels obtained in Step 7. Once the levels have been revised, the tone-correction factor must be recomputed for the revised one-third-octave-band spectrum. This recomputed maximum tone-correction factor must be applied, even if it occurs at or near the band associated with an artificial tone, and FAA approval must be obtained for the methodology used.

196. Section A36.4.3.2

The tone correction procedure will underestimate EPNL if an important tone is of a frequency such that it is recorded in two adjacent one-third octave bands. An applicant must demonstrate that either:

- (a) No important tones are recorded in two adjacent one-third octave bands; or***
- (b) That if it has occurred that the tone correction has been adjusted to the value it would have had if the tone had been recorded fully in a single one-third octave band.***

a. Supplemental Information

- (1) Bandsharing is discussed under Section A36.4.4.2.

197. Section A36.4.4 Maximum Tone-Corrected Perceived Noise Level

198. Section A36.4.4.1

The maximum tone-corrected perceived noise level, PNL_{TM}, must be the maximum calculated value of the tone-corrected perceived noise level PNL_{T(k)}. It must be calculated using the

procedure of section A36.4.3. To obtain a satisfactory noise time history, measurements must be made at 0.5 second time intervals.

Note 1: Figure A36-2 is an example of a flyover noise time history where the maximum value is clearly indicated.

Note 2: In the absence of a tone correction factor, PNLTM would equal PNLM.

199. Section A36.4.4.2

After the value of PNLTM is obtained, the frequency band for the largest tone correction factor is identified for the two preceding and two succeeding 500 ms data samples. This is performed in order to identify the possibility of tone suppression at PNLTM by one-third octave band sharing of that tone. If the value of the tone correction factor $C(k)$ for PNLTM is less than the average value of $C(k)$ for the five consecutive time intervals, the average value of $C(k)$ must be used to compute a new value for PNLTM.

a. Explanation

This section specifies a method of accounting for the effects of the suppression of tones occurring at or near the band edges of one-third-octave-band filters when determining a tone correction factor at the time of PNLTM.

b. Supplemental Information

- (1) Band-sharing Adjustment Concept: The one-third-octave-band filtering process specified for analysis of airplane noise certification data may allow the tone-correction procedure presented in Section A36.4.3 to underpredict the annoyance factor of a tone when its frequency is located at or near the edge of one or more one-third-octave bands. To account for this phenomenon, a bandsharing adjustment is computed that takes advantage of the fact that, as a result of the Doppler Effect, a tone that is suppressed at PNLTM will probably appear normally in the spectra that occur before or after PNLTM. By averaging the tone corrections calculated for the spectra within a 2-second period around PNLTM, the tone correction that would have occurred at PNLTM if it were not suppressed can be reasonably estimated.

c. Procedures

- (1) Computation of Bandsharing Adjustment: Although Part 36 refers to identification of the frequency bands in which maximum tone-corrections occur for the records near PNLTM, the presence or absence of bandsharing cannot be established merely by observing these frequencies. Even though the ***maximum***

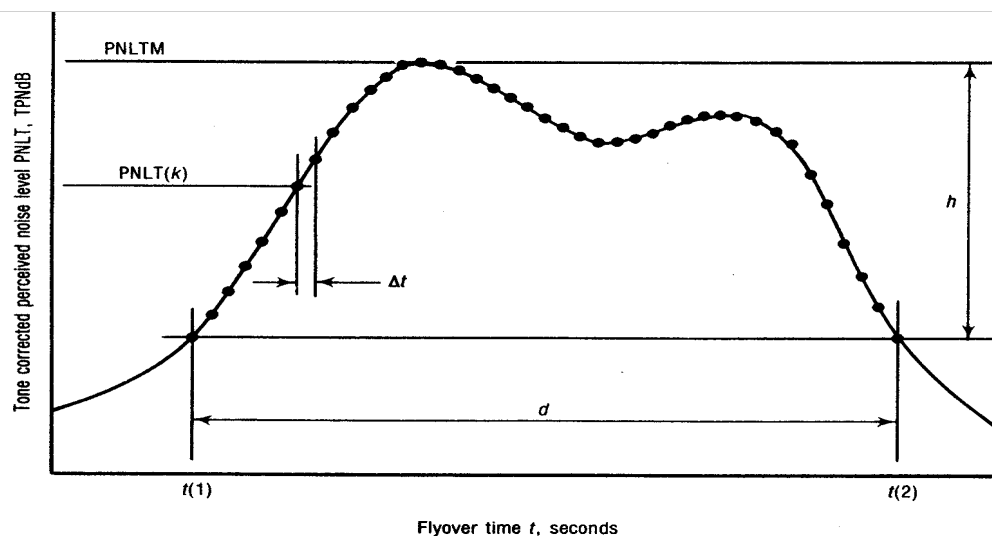


Figure A36-2: Example of Perceived Noise Level Corrected for Tones as a Function of Aircraft Flyover Time

tone that occurs in a one-third-octave band spectrum may not be related to the band of maximum tone-correction in the PNLTM spectrum, a related tone may still be present. Therefore, the average of the tone-corrections of all spectra within 1-second (five 1/5-second data records) of PNLTM must be used regardless of the bands in which maximum tones are found. If the bandsharing adjustment is believed to result from effects other than bandsharing, the applicant must demonstrate its absence for each event.

- (2) Adjustment of PNLTM for Bandsharing: The bandsharing adjustment must be computed before the determination of the 10 dB-down period and must be included in the reported PNLTM and EPNL values for the test-day data.
- (3) Application of Bandsharing Adjustment for Simplified Procedure: When the simplified procedure is used to adjust data to reference conditions, the Bandsharing adjustment, must be applied to the reference-day PNLTM before "delta 1" (and the reference-day EPNL) is calculated.
- (4) Application of Bandsharing Adjustment for Integrated Procedure: When the integrated procedure is used to adjust data to reference conditions, a new reference-day bandsharing adjustment must be computed from the reference-day PNL T values for the one-third-octave-band spectra within one second (five data records) of the reference-day PNLTM.

200. Section A36.4.5 Duration Correction

201. Section A36.4.5.1

The duration correction factor D determined by the integration technique is defined by the expression:

$$D = 10 \log \left[\left(\frac{1}{T} \right) \int_{t(1)}^{t(2)} \text{antilog} \frac{PNLT}{10} dt \right] - PNLTM$$

where T is a normalizing time constant, $PNLTM$ is the maximum value of $PNLT$, $t(1)$ is the first point of time after which $PNLT$ becomes greater than $PNLTM-10$, and $t(2)$ is the point of time after which $PNLT$ remains constantly less than $PNLTM-10$.

202. Section A36.4.5.2

Since $PNLT$ is calculated from measured values of sound pressure level (SPL), there is no obvious equation for $PNLT$ as a function of time. Consequently, the equation is to be rewritten with a summation sign instead of an integral sign as follows:

$$D = 10 \log \left[\left(\frac{1}{T} \right) \sum_{k=0}^{d/Dt} Dt \cdot \text{anti log} \frac{PNLT(k)}{10} \right] - PNLTM$$

where Dt is the length of the equal increments of time for which $PNLT(k)$ is calculated and d is the time interval to the nearest 0.5s during which $PNLT(k)$ remains greater or equal to $PNLTM-10$.

203. Section A36.4.5.3

To obtain a satisfactory history of the perceived noise level use one of the following:

- (a) Half-second time intervals for Dt ; or
- (b) A shorter time interval with approved limits and constants.

204. Section A36.4.5.4

The following values for T and Dt must be used in calculating D in the equation given in section A36.4.5.2:

$T = 10$ s, and

$Dt = 0.5$ s (or the approved sampling time interval).

Using these values, the equation for D becomes:

$$D = 10 \log \left[\sum_{k=0}^{2d} \text{anti log} \frac{PNLT(k)}{10} \right] - PNLTM - 13$$

where d is the duration time defined by the points corresponding to the values $PNLTM-10$.

a. Supplemental Information

- (1) EPNL Equations: The equation for the duration correction, D , as shown in A36.4.5.4, is valid only for records of $\frac{1}{2}$ second in length. The constant value 13 is used to normalize the $\frac{1}{2}$ second values to the 10-second comparison duration ($10 \cdot \log_{10}$ (10 seconds of $\frac{1}{2}$ second data records = 20 records) = 13.01).

205. Section A36.4.5.5

If in using the procedures given in section A36.4.5.2, the limits of $PNLTM-10$ fall between the calculated $PNLT(k)$ values (the usual case), the $PNLT(k)$ values defining the limits of the duration interval must be chosen from the $PNLT(k)$ values closest to $PNLTM-10$. For those cases with more

than one peak value of $PNLT(k)$, the applicable limits must be chosen to yield the largest possible value for the duration time.

a. Explanation

This section specifies a requirement to calculate a duration correction, D , which is determined by means of integrating (summing) the $PNLT$ values within 10 dB of $PNLTM$.

c. Procedures

- (1) Identification of the First and Last Records Within the 10 dB-Down Period: When identifying the records that define the limits of the 10 dB-down period, those records having $PNLT$ values **closest** to the actual value of $PNLTM-10$ dB must be used. As a result, the $PNLTM-10$ dB points may not always occur within the 10 dB-down period.
- (2) Calculation of the Duration Correction, D : When calculating the value of D , the full $PNLT$ value and duration of each record within the 10 dB-down period must be included. Interpolation of $PNLT$ values to the point of $PNLTM-10$ dB is not allowed.
- (3) Recorded Data: If recorded data do not encompass the entire 10 dB-down period, an $EPNL$ cannot be calculated from those data, and the event must not be used for aircraft noise certification purposes.

206. Section A36.4.6 Effective Perceived Noise Level

207. Section A36.4.6.1

A36.4.6.1 The total subjective effect of an airplane noise event, designated effective perceived noise level, $EPNL$, is equal to the algebraic sum of the maximum value of the tone-corrected perceived noise level, $PNLTM$, and the duration correction D . That is:

$$EPNL = PNLTM + D$$

where $PNLTM$ and D are calculated using the procedures given in sections A36.4.2, A36.4.3, A36.4.4. and A36.4.5.

208. Section A36.4.7 Mathematical formulation of noy tables

209. Section A36.4.7.1

The relationship between sound pressure level (SPL) and the logarithm of perceived noisiness is illustrated in Figure A36-3 and Table A36-3.

210. Section A36.4.7.2

The bases of the mathematical formulation are:

- (a) The slopes ($M(b)$, $M(c)$, $M(d)$ and $M(e)$) of the straight lines;***
- (b) The intercepts ($SPL(b)$ and $SPL(c)$) of the lines on the SPL axis; and***
- (c) The coordinates of the discontinuities, $SPL(a)$ and $\log n(a)$; $SPL(d)$ and $\log n = -1.0$; and $SPL(e)$ and $\log n = \log (0.3)$.***

211. Section A36.4.7.3 Calculate noy values using the following equations:

(a)

$$\text{SPL} \geq \text{SPL}(a)$$

$$n = \text{antilog}\{M(c)[\text{SPL} - \text{SPL}(c)]\}$$

(b)

$$\text{SPL}(b) \leq \text{SPL} < \text{SPL}(a)$$

$$n = \text{antilog}\{M(b)[\text{SPL} - \text{SPL}(b)]\}$$

(c)

$$\text{SPL}(e) \leq \text{SPL} < \text{SPL}(b)$$

$$n = 0.3 \text{antilog}\{M(e)[\text{SPL} - \text{SPL}(e)]\}$$

(d)

$$\text{SPL}(d) \leq \text{SPL} < \text{SPL}(e)$$

$$n = 0.1 \text{ antilog}\{M(d)[\text{SPL} - \text{SPL}(d)]\}$$

212. Section A36.4.7.4

Table A36-3 lists the values of the constants necessary to calculate perceived noisiness as a function of sound pressure level.

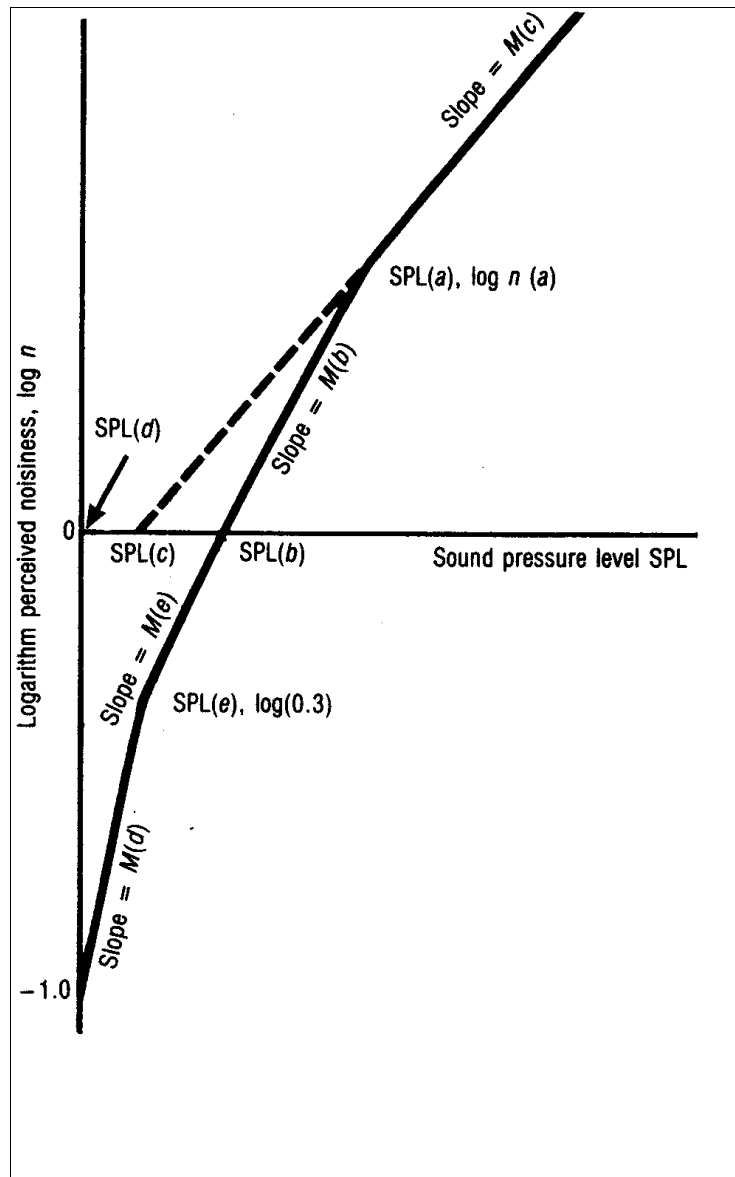


Figure A36-3: Perceived noisiness as a function of sound pressure level

BAND (i)	f HZ	SPL (a)	SPL (b)	SPL (c)	SPL (d)	SPL (e)	M(b)	M(c)	M(d)	M(e)
1	50	91.0	64	52	49	55	0.043478	0.030103	0.079520	0.058098
2	63	85.9	60	51	44	51	0.040570		0.068160	"
3	80	87.3	56	49	39	46	0.036831		"	0.052288
4	100	79.9	53	47	34	42	"		0.059640	0.047534
5	125	79.8	51	46	30	39	0.035336		0.053013	0.043573
6	160	76.0	48	45	27	36	0.033333			"
7	200	74.0	46	43	24	33	"	0.040221		
8	250	74.9	44	42	21	30	0.032051	0.037349		
9	315	94.6	42	41	18	27	0.030675	<u>0.030103</u>		0.034859
10	400		40	40	16	25	0.030103	NOT APPLICABLE		
11	500		40	40	16	25				
12	630		40	40	16	25				
13	800		40	40	16	25				
14	1 000		40	40	16	25				
15	1 250	38	38	15	23	0.030103	0.053013		0.034859	
16	1 600	34	34	12	21	0.029960	0.053013		0.040221	
17	2 000	32	32	9	18		"		0.037349	
18	2 500	30	30	5	15		0.047712		0.034859	
19	3 150	29	29	4	14		"			
20	4 000	29	29	5	14		0.053013			
21	5 000	30	30	6	15		"		0.034859	
22	6 300	∞	31	31	10	17	0.029960		0.068160	0.037349
23	8 000	44.3	37	34	17	23	0.042285	<u>0.029960</u>	0.079520	"
24	10 000	50.7	41	37	21	29	"	"	0.059640	0.043573

Table A36-3: Constants for mathematically formulated noy values.

a. Explanation

This section specifies a requirement for using table A36-3 constants to calculate perceived noy values related to sound-pressure-level values.

213. Section A36.5. Reporting of Data to the FAA

214. Section A36.5.1 General

215. Section A36.5.1.1

Data representing physical measurements and data used to make corrections to physical measurements must be recorded in an approved permanent form and appended to the record.

216. Section A36.5.1.2

All corrections must be reported to and approved by the FAA. In particular, the corrections to measurements for equipment response deviations must be reported.

217. Section A36.5.1.3

Applicants may be required to submit estimates of the individual errors inherent in each of the operations employed in obtaining the final data.

a. Explanation

This section specifies a requirement that all data measured during noise certification testing, including all time histories of physical measurements, noise recordings, instrument calibrations, etc., are to be recorded in permanent form and made available to the FAA for review, inspection, and approval upon request. A common equivalent procedure (approved by the FAA) is for the applicant to submit representative samples of test data for each noise measurement point and adjustments to measured data to permit the FAA to conduct a regulatory compliance evaluation.

b. Supplemental Information

- (1) Compliance Records: Results and records of noise certification tests and data evaluations are to be transmitted to the FAA ACO as compliance records. The applicant may either: 1.) submit the complete test records along with the required corrections, or 2.) when approved by the FAA, the applicant may submit samples of test data along with the required data adjustments.
- (2) Company Compliance Records: Company compliance records shall be identified and considered proprietary, may not be presented to others without explicit written permission of the applicant, and may be requested to be returned to the applicant following review by the FAA. Detailed information in these records may be needed by an ACO specialist to determine regulatory compliance. The FAA is required by law to respect the restrictive nature of all proprietary company data and cannot copy or distribute such data.

c. Procedures

- (1) Test Records: All test records are to be submitted to the FAA for compliance review and approval. Adjustments to the measured data are also to be submitted to the FAA for review and approval. The FAA may require an applicant to submit the magnitude of potential errors at each step in the measurement, analysis, and adjustment of data. Specific data-reporting requirements are identified in Section A36.5.2.
- (2) FAA Handling of Compliance Records: FAA handling of compliance records will be as follows:
 - All certification compliance records are to be made available to the FAA upon request. The applicant may request that the FAA return the certification compliance records following inspection, evaluation, and approval.
 - Applicants may identify records that they consider to be proprietary and that they do not want the FAA to distribute to others without explicit written permission from the applicant. The FAA is required by law, to respect the restrictive nature of all proprietary company data and prohibits the FAA from copying or distributing such data.

218. Section A36.5.2 Data Reporting

The following must be reported to the FAA in the applicant's noise certification compliance report.

219. Section A36.5.2.1

The applicant must present measured and corrected sound pressure levels in one-third octave band levels that are obtained with equipment conforming to the standards described in section A36.3 of this appendix.

220. Section A36.5.2.2

The applicant must report the make and model of equipment used for measurement and analysis of all acoustic performance and meteorological data.

221. Section A36.5.2.3

The applicant must report the following atmospheric environmental data, as measured immediately before, after, or during each test at the observation points prescribed in section A36.2 of this appendix.

- (a) Air temperature and relative humidity;***
- (b) Maximum, minimum and average wind velocities; and***
- (c) Atmospheric pressure.***

222. Section A36.5.2.4

The applicant must report conditions of local topography, ground cover, and events that might interfere with sound recordings.

223. Section A36.5.2.5

The applicant must report the following:

- (a) Type, model and serial numbers (if any) of airplane, engine(s), or propeller(s) (as applicable);***
- (b) Gross dimensions of airplane and location of engines;***
- (c) Airplane gross weight for each test run and center of gravity range for each series of test runs;***
- (d) Airplane configuration such as flap, airbrakes and landing gear positions and propeller pitch angles (if applicable) for each test run;***
- (e) Whether auxiliary power units (APU), when fitted, are operating for each test run;***
- (f) Status of pneumatic engine bleeds and engine power take-offs for each test run;***
- (g) Indicated airspeed in knots or kilometers per hour for each test run;***
- (h) Engine performance data:***
 - (1) For jet airplanes: engine performance in terms of net thrust, engine pressure ratios, jet exhaust temperatures and fan or compressor shaft rotational speeds as determined from airplane instruments and manufacturer's data for each test run;***
 - (2) For propeller-driven airplanes: engine performance in terms of brake horsepower and residual thrust; or equivalent shaft horsepower; or engine torque and propeller rotational speed; as determined from airplane instruments and manufacturer's data for each test run;***
- (i) Airplane flight path and ground speed during each test run; and***
- (j) The applicant must report whether the airplane has any modifications or non-standard equipment likely to affect the noise characteristics of the airplane. Any such modifications or non-standard equipment must be approved by the FAA.***

a. Explanation

This section specifies the noise certification data-reporting requirements.

b. Supplemental Information

- (1) Reporting Requirements: Noise certification data reporting requirements include -
- i. One-third-octave-band sound pressure levels
 - ii. Equipment used for acoustical measurement and analysis
 - iii. Equipment used for determining airplane performance, meteorological conditions, and upper atmospheric conditions
 - iv. Test site characteristics, including topography, ground cover, and any events that could affect the sound recordings
 - v. Airplane information, including: airplane type, model, and general configuration; engine serial numbers; airplane gross weight, etc.
 - vi. Test conditions throughout the 10 dB-down period, including test airspeed, engine performance parameters, and airplane flight path position
 - vii. Recorder sampling rates
 - viii. Airplane and engine performance information, including airplane altitude, climb angle, airspeed and gross weight, flap and gear position, engine power setting parameters (e.g., compressor rotor speed, engine pressure ratio, exhaust gas temperature), and airplane accessory condition (e.g., A/C and APU "on" or "off"). Any other parameters that may affect the measurement or adjustment of acoustical, airplane, or engine performance data should also be recorded throughout the 10 dB-down period (e.g., SBV position, CG position).

224. Section A36.5.3 Reporting of noise certification reference conditions.

225. Section A36.5.3.1

Airplane position and performance data and the noise measurements must be corrected to the noise certification reference conditions specified in the relevant sections of appendix C of this part. The applicant must report these conditions, including reference parameters, procedures and configurations.

a. Explanation

This section specifies a requirement to report reference conditions, parameters, procedures, and configurations used for noise certification testing.

b. Supplemental Information

- (1) Reference Conditions: Reference conditions, and reference airplane parameters, procedures, and configurations for noise certification are as follows:

(a) Reference atmospheric conditions are:

- Sea level with a standard atmospheric pressure equal to 2,116 psf (29.92 inches of mercury, 1013 millibars, 11.325 kPa)
- 77°Fahrenheit (25°Celsius) atmospheric temperature
- 70 percent atmospheric relative humidity
- Zero wind in any direction.

(b) Reference airplane performance conditions are:

- Take-off from or landing on a level airport runway
- Gross weights:
 - Take-off – Maximum certificated takeoff gross weight
 - Approach/landing – Maximum certificated landing weight

- Flap position set at:
Flyover and Lateral – Any approved airworthiness setting selected by the applicant.
Approach – Setting for which the approach noise is most critical, (i.e. the loudest).
- Engine power set at:
Flyover – at maximum certificated takeoff power (with optional cutback power).
Lateral – at maximum certificated takeoff power.
Approach/Landing – Power required to maintain a -3° glide angle at $V_{ref} + 10$ knots.
- Reference approved airplane flight height which occurs when the plane is at the following:
Flyover – At 21,325 feet (6,500 meters) from brake release.
Lateral – When the noise is maximum during take-off, as measured at a distance of 1,476 feet (450 meters) parallel to the extended runway centerline.
Approach/landing – at 6,562 feet (2,000 meters) from the runway threshold; the airplane height at this position is 394 feet (120 meters) above the approach noise measurement point.
- Other operational conditions:
Flyover - none
Approach - those in-flight approved configurations for which the approach noise is most critical (e.g., in-flight operable APU, noise critical CG, A/C "ON", etc.).

- (2) Equivalent Procedures: FAA does not approve equivalent procedures for noise certification reference conditions.
- (3) DER Information: Reference airplane performance is to be FAA approved based on approved data. This may require that a flight analyst DER with appropriate authority for Part 36 reference airplane performance submit a FAA Form 8110-3 for review by the approving FAA flight test branch of the ACO. (See the DER Guidance Handbook, ref. 3.i. for additional information.)

226. Section A36.5.4 Validity of results.

227. Section A36.5.4.1

Three average reference EPNL values and their 90 per cent confidence limits must be produced from the test results and reported, each such value being the arithmetical average of the adjusted acoustical measurements for all valid test runs at each measurement point (flyover, lateral, or approach. If more than one acoustic measurement system is used at any single measurement location, the resulting data for each test run must be averaged as a single measurement. The calculation must be performed by:

(a) Computing the arithmetic average for each flight phase using the values from each microphone point; and

(b) Computing the overall arithmetic average for each reference condition (flyover, lateral or approach) using the values in paragraph (a) of this section and the related 90 per cent confidence limits.

228. Section A36.5.4.2

For each of the three certification measuring points, the minimum sample size is six. The sample size must be large enough to establish statistically for each of the three average noise certification levels a 90 per cent confidence limit not exceeding ± 1.5 EPNdB. No test result may be omitted from the averaging process unless approved by the FAA.

Note: Methods available for calculating the 90 per cent confidence interval are shown in the current Advisory Circular for this part.

229. Section A36.5.4.3

The average EPNL figures obtained by the process described in section A36.5.4.1 must be those by which the noise performance of the airplane is assessed against the noise certification criteria.

a. Explanation

This section specifies that reference mean EPNL values for the flyover, lateral and approach noise measurement points are to be within a 90 percent confidence interval limit of ± 1.5 dB. Both the mean EPNL levels and the associated confidence intervals are to be reported.

b. Supplemental Information

- (1) Mean EPNL Levels: The arithmetic mean of the adjusted EPNL is to be reported in a noise certification compliance document for flyover, lateral, and approach. The mean EPNL value of n clustered data points, L_1, L_2, \dots, L_n , is: $L_{\text{mean}} = (L_1 + L_2 + \dots + L_n)(1/n)$. The mean EPNL value from an NPD database is the noise level determined along the regression line through the adjusted data set at the appropriate power and distance values.
- (2) 90 Percent Confidence Interval (Clustered Data): The test methods described in Part 36 are conducted for a minimum of six duplicate noise measurements for each of the three noise measurement points (flyover, lateral and approach). These duplicate tests create three clusters of data for correction and evaluation. The 90 percent confidence interval validity evaluation of clusters of data can be easily determined. If n measurements of EPNL, L_1, L_2, \dots, L_n , are obtained under approximately the same conditions and it can be assumed that they constitute a random sample from a normal population, then the statistical 90 percent confidence interval value for each clustered group can be derived.
- (3) 90 Percent Confidence Interval (NPD Database): Noise-Power-Distance (NPD) database confidence intervals are determined by using a more general formulation than that used for a normal cluster of data points. The confidence interval is to be calculated about each data regression line, whether it is generated for flight test data, a combination of flight test and static test data, or analytical results.
- (4) Single Test Values: When more than one noise measurement system is used at any one noise measurement point, the resulting noise level is to be the average of the measured noise levels for each noise measurement point. Some applicants prefer to provide multiple microphones at each noise measurement point. When multiple microphones are used during the noise testing, the average noise level is to be reported for each noise measurement.
- (5) Valid Conditions: All valid noise measurements that are witnessed by an FAA observer or an appropriate designee and determined to be valid are to be included in the confidence interval calculations even when they produce results that are outside the 90 percent confidence limit of ± 1.5 dB. The cause of erratic or possibly invalid noise data may include: testing under different temperature and humidity extremes, anomalous winds aloft, changes in measuring and recording equipment, changes in airplane hardware, background noise, shift in instrument calibrations, not testing in accordance with the approved test plan, etc. The FAA observer is to make a determination, during the course of noise certification testing, as to the validity of all noise measurements. A noise measurement may not be excluded from the confidence interval calculations at a later date without FAA approval. Noise measurements determined in the field to be invalid for any reason must be repeated.

c. Procedures

- (1) Applicant's Responsibility: An applicant is responsible not only for the development of equivalent procedures but also for the development of procedures to quantify a 90 percent confidence interval determination when the approved equivalent procedures are used. The confidence interval procedures that are used in conjunction with approved equivalent procedures may be unique to each of the three measurement conditions (flyover, lateral and approach) and may be suitable for either simplified or integrated methods of evaluating the corrected EPNL levels.
- (2) Methods for Calculating 90 percent Confidence Interval: Calculation methods for determining the 90 percent confidence interval values for clustered and some other approved test results are presented in Appendix 1 of the appended ICAO TM. The TM provides confidence interval calculation methods for: clustered measurements, regression mean line, static test-derived NPD curves, and analytically derived NPD curves, and provides working examples (clustered, first-order regression curve, second-order regression curve, and the pooled data set).
- (3) Reporting Requirements: Reference EPNL levels for each of the three noise measurement points (flyover, lateral, and approach) and the associated values of the 90% confidence intervals are to be reported to the FAA in noise certification compliance documentation.
- (4) Retest Requirements: The FAA may require an applicant to retest or provide additional test data for any of the three noise measurement points (flyover, lateral or approach) when the reported results indicate:
 - i. A required measurement is reported to be invalid, or
 - ii. An insufficient number of measurements were conducted by the applicant to determine a suitable data sample, or
 - iii. Data scatter indicates that the data are not from a normal population or trend (e.g., a discontinuity due to low power SBV operation), or
 - iv. The 90 percent confidence interval for a noise measuring condition exceeds the allowable ± 1.5 dB, or
 - v. The test was not conducted in accordance with an approved noise certification compliance demonstration plan.

230. Section A36.6 Nomenclature: Symbols and Units

Symbol	Unit	Meaning
Antilog	-	Antilogarithm to the base 10.
C(k)	dB	<u>Tone correction factor.</u> The factor to be added to PNL(k) to account for the presence of spectral irregularities such as tones at the k-th increment of time.
D	s	<u>Duration time.</u> The time interval between the limits of t(1) and t(2) to the nearest 0.5 second.
D	dB	<u>Duration correction.</u> The factor to be added to PNLT_M to account for the duration of the noise.
EPNL	EPNdB	<u>Effective perceived noise level.</u> The value of PNL adjusted for both spectral irregularities and duration of the noise. (The unit EPNdB is used instead of the unit dB).
f(i)	Hz	<u>Frequency.</u> The geometrical mean frequency for the i-th one-third octave band.
F(i,k)	dB	<u>Delta-dB.</u> The difference between the original sound pressure level and the final background sound pressure level in the i-th one-third octave band at the k-th interval of time. In this case, background sound pressure level means the broadband noise level that would be present in the one-third octave band in the absence of the tone.
H	dB	<u>dB-down.</u> The value to be subtracted from PNLT_M that defines the duration of the noise.
H	per cent	<u>Relative humidity.</u> The ambient atmospheric relative humidity.
I	-	<u>Frequency band index.</u> The numerical indicator that denotes any one of the 24 one-third octave bands with geometrical mean frequencies from 50 to 10,000 Hz.
K	-	<u>Time increment index.</u> The numerical indicator that denotes the number of equal time increments that have elapsed from a reference zero.
Log	-	Logarithm to the base 10.
log n(a)	-	<u>Noy discontinuity coordinate.</u> The log n value of the intersection point of the straight lines representing the variation of SPL with log n.
M(b), M(c), etc.	-	<u>Noy inverse slope.</u> The reciprocals of the slopes of straight lines representing the variation of SPL with log n.

N	noy	<i>The perceived noisiness at any instant of time that occurs in a specified frequency range.</i>
$n(i,k)$	noy	<i>The perceived noisiness at the k-th instant of time that occurs in the i-th one-third octave band.</i>
$n(k)$	noy	<i><u>Maximum perceived noisiness.</u> The maximum value of all of the 24 values of $n(i)$ that occurs at the k-th instant of time.</i>
$N(k)$	noy	<i><u>Total perceived noisiness.</u> The total perceived noisiness at the k-th instant of time calculated from the 24-instantaneous values of $n(i,k)$.</i>
$p(b), p(c), \text{etc.}$	-	<i><u>Noy slope.</u> The slopes of straight lines representing the variation of SPL with log n.</i>
PNL	PNdB	<i>The perceived noise level at any instant of time. (The unit PNdB is used instead of the unit dB).</i>
PNL(k)	PNdB	<i>The perceived noise level calculated from the 24 values of SPL (i,k), at the k-th increment of time. (The unit PNdB is used instead of the unit dB).</i>
PNLM	PNdB	<i><u>Maximum perceived noise level.</u> The maximum value of PNL(k). (The unit PNdB is used instead of the unit dB).</i>
PNLT	TPNdB	<i><u>Tone-corrected perceived noise level.</u> The value of PNL adjusted for the spectral irregularities that occur at any instant of time. (The unit TPNdB is used instead of the unit dB).</i>
PNLT(k)	TPNdB	<i>The tone-corrected perceived noise level that occurs at the k-th increment of time. PNL(k) is obtained by adjusting the value of PNL(k) for the spectral irregularities that occur at the k-th increment of time. (The unit TPNdB is used instead of the unit dB).</i>
PNLTM	TPNdB	<i><u>Maximum tone-corrected perceived noise level.</u> The maximum value of PNL(k). (The unit TPNdB is used instead of the unit dB).</i>
PNLT_r	TPNdB	<i>Tone-corrected perceived noise level adjusted for reference conditions.</i>
$s(i,k)$	dB	<i><u>Slope of sound pressure level.</u> The change in level between adjacent one-third octave band sound pressure levels at the i-th band for the k-th instant of time.</i>
$\Delta s(i,k)$	dB	<i>Change in slope of sound pressure level..</i>
$s'(i,k)$	dB	<i>Adjusted slope of sound pressure level. The change in level between adjacent adjusted one-third octave band sound pressure levels at the i-th band for the k-th instant of time.</i>

$\bar{s}(i,k)$	dB	<i>Average slope of sound pressure level.</i>
SPL	dB re 20 μ Pa	<i><u>Sound pressure level.</u> The sound pressure level that occurs in a specified frequency range at any instant of time.</i>
SPL(a)	dB re 20 μ Pa	<i><u>Noy discontinuity coordinate.</u> The SPL value of the intersection point of the straight lines representing the variation of SPL with log n.</i>
SPL(b) SPL(c)	dB re 20 μ Pa	<i><u>Noy intercept.</u> The intercepts on the SPL-axis of the straight lines representing the variation of SPL with log n.</i>
SPL(i,k)	dB re 20 μ Pa	<i>The sound pressure level at the k-th instant of time that occurs in the i-th one-third octave band.</i>
SPL'(i,k)	dB re 20 μ Pa	<i><u>Adjusted sound pressure level.</u> The first approximation to background sound pressure level in the i-th one-third octave band for the k-th instant of time.</i>
SPL(i)	dB re 20 μ Pa	<i><u>Maximum sound pressure level.</u> The sound pressure level that occurs in the i-th one-third octave band of the spectrum for PNLTM.</i>
SPL(i) _r	dB re 20 μ Pa	<i><u>Corrected maximum sound pressure level.</u> The sound pressure level that occurs in the i-th one-third octave band of the spectrum for PNLTM corrected for atmospheric sound absorption.</i>
SPL"(i,k)	dB re 20 μ Pa	<i><u>Final background sound pressure level.</u> The second and final approximation to background sound pressure level in the i-th one-third octave band for the k-th instant of time.</i>
<i>t</i>	s	<i><u>Elapsed time.</u> The length of time measured from a reference zero.</i>
<i>t</i> (1), <i>t</i> (2)	s	<i><u>Time limit.</u> The beginning and end, respectively, of the noise time history defined by h.</i>
Δt	s	<i><u>Time increment.</u> The equal increments of time for which PNL(k) and PNLT(k) are calculated.</i>
<i>T</i>	s	<i><u>Normalizing time constant.</u> The length of time used as a reference in the integration method for computing duration corrections, where $T = 10$s.</i>
<i>t</i> (°F)(°C)	°F °C	<i><u>Temperature.</u> The ambient air temperature.</i>
$\alpha(i)$	dB/100ft dB/100m	<i><u>Test atmospheric absorption.</u> The atmospheric attenuation of sound that occurs in the i-th one-third octave band at the measured air temperature and relative humidity.</i>

$\alpha(i)_O$	dB/100ft dB/100m	<u>Reference atmospheric absorption.</u> The atmospheric attenuation of sound that occurs in the <i>i</i> -th one-third octave band at a reference air temperature and relative humidity.
A_1	degrees	<i>First constant climb angle (Gear up, speed of at least V_2+10 kt ($V_2 +19$ km/h), takeoff thrust)</i>
A_2	degrees	<i>Second constant climb angle (Gear up, speed of at least V_2+10 kt ($V_2 +19$ km/h), after cut-back)</i>
δ ϵ	degrees	<u>Thrust cutback angles.</u> The angles defining the points on the takeoff flight path at which thrust reduction is started and ended respectively.
η	degrees	<i>Approach angle.</i>
η_r	degrees	<i>Reference approach angle.</i>
θ	degrees	<u>Noise angle (relative to flight path) .</u> The angle between the flight path and noise path. It is identical for both measured and corrected flight paths.
ϕ	degrees	<u>Noise angle (relative to ground).</u> The angle between the noise paths and the grounds. It is identical for both measured and corrected flight paths. .
μ		<i>Engine noise emission parameter.</i>
Δ_1	EPNdB	<u>PNLT correction.</u> The correction to be added to the EPNL calculated from measured data to account for noise level changes due to differences in atmospheric absorption and noise path length between reference and test conditions.
Δ_2	EPNdB	<u>Adjustment to duration correction.</u> The adjustment to be made to the EPNL calculated from measured data to account for noise level changes due to the noise duration between reference and test conditions.
Δ_3	EPNdB	<u>Source noise adjustment.</u> The adjustment to be made to the EPNL calculated from measured data to account for noise level changes due to differences between reference and test engine operating conditions.

a. Explanation

This section contains standard noise symbols, their associated units, and the meaning of terms that are used during the testing, analysis, and evaluation of airplane noise certification.

b. Supplementary Information

- (1) Common Symbols: Some of the airplane noise certification symbols identified in this section may also be common to other aircraft noise certification activities, such as the noise certification of small airplanes and rotorcraft.

c. Procedures

Symbol Questions: If an applicant has any question regarding the airplane noise certification symbols, their units, or their meanings, the applicant should contact the appropriate Noise Certification Specialist (NCS) for clarification. The NCS will then contact AEE and/or VNTSC for further clarification, if needed.

231. **Section A36.7 Sound Attenuation in Air**232. **Section A36.7.1**

The atmospheric attenuation of sound must be determined in accordance with the procedure presented in section A36.7.2.

233. **Section A36.7.2**

The relationship between sound attenuation, frequency, temperature, and humidity is expressed by the following equations.

A36.7.2(a) For calculations using the English System of Units:

$$\mathbf{a}(i) = 10^{\left[2.05 \log(f_0/1000) + 6.33 \times 10^{-4} \mathbf{q} - 1.45325 \right]}$$

$$+ \mathbf{h}(\mathbf{d}) \times 10^{\left[\log(f_0) + 4.6833 \times 10^{-3} \mathbf{q} - 2.4215 \right]}$$

and

$$\mathbf{d} = \sqrt{\frac{1010}{f(0)}} 10^{\left(\log H - 1.97274664 + 2.288074 \times 10^{-2} \mathbf{q} \right)}$$

$$\times 10^{\left(-9.589 \times 10^{-5} \mathbf{q}^2 + 3.0 \times 10^{-7} \mathbf{q}^3 \right)}$$

where

$\mathbf{h}(\mathbf{d})$ is listed in Table A36-4 and f_0 in Table A36-5;

$\mathbf{a}(i)$ is the attenuation coefficient in dB/1000 ft;

\mathbf{q} is the temperature in °F; and

H is the relative humidity, expressed as a percentage.

A36.7.2(b) For calculations using the International System of Units (SI):

$$\mathbf{a}(i) = 10^{\left[2.05 \log(f_0/1000) + 1.1394 \times 10^{-3} \mathbf{q} - 1.916984 \right]}$$

$$+ \mathbf{h}(\mathbf{d}) \times 10^{\left[\log(f_0) + 8.42994 \times 10^{-3} \mathbf{q} - 2.755624 \right]}$$

and

$$d = \sqrt{\frac{1010}{f_0}} 10^{\left(\log H - 1.328924 + 3.179768 \times 10^{-2} q \right)} \\ \times 10^{\left(-2.173716 \times 10^{-4} q^2 + 1.7496 \times 10^{-6} q^3 \right)}$$

where

$h(d)$ is listed in Table A36-4 and f_0 in Table A36-5;

$a(i)$ is the attenuation coefficient in dB/100 m;

q is the temperature in °C; and

H is the relative humidity, expressed as a percentage.

234. Section A36.7.3

The values listed in table A36-4 are to be used when calculating the equations listed in section A36.7.2. A term of quadratic interpolation is to be used where necessary.

Table A36-4. Values of $\eta(\delta)$

δ	$\eta(\delta)$	δ	$\eta(\delta)$
0.00	0.000	2.50	0.450
0.25	0.315	2.80	0.400
0.50	0.700	3.00	0.370
0.60	0.840	3.30	0.330
0.70	0.930	3.60	0.300
0.80	0.975	4.15	0.260
0.90	0.996	4.45	0.245
1.00	1.000	4.80	0.230
1.10	0.970	5.25	0.220
1.20	0.900	5.70	0.210
1.30	0.840	6.05	0.205
1.50	0.750	6.50	0.200
1.70	0.670	7.00	0.200
2.00	0.570	10.00	0.200
2.30	0.495		

Table A36-5. Values of f_0

one-third octave centre frequency	f_0 (Hz)	one-third octave centre frequency	f_0 (Hz)
50	50	800	800
63	63	1000	1000
80	80	1250	1250
100	100	1600	1600
125	125	2000	2000
160	160	2500	2500
200	200	3150	3150
250	250	4000	4000
315	315	5000	4500
400	400	6300	5600
500	500	8000	7100
630	630	10000	9000

a. Explanation

This section specifies equations for calculating the atmospheric attenuation of sound.

b. Supplemental Information

- (1) Data Adjustments for Effects of Atmospheric Attenuation: Ambient temperature and relative humidity conditions in the atmosphere result in attenuation of sound propagating from a test airplane to the noise certification measurement points. When test day ambient temperature and relative humidity conditions differ from reference conditions, the airplane noise data must be adjusted to reference conditions by an FAA-approved method, as discussed in Section A36.9.3.2.1.
- (2) Adjustments to One-Third-Octave-Band Data: When an applicant uses the simplified adjustment method, as discussed in Section A36.9.3 of this AC, the atmospheric attenuation adjustments are applied to the measured PNLTM spectrum. When the applicant uses the integrated adjustment method, as discussed in Section A36.9.4 of this AC, the atmospheric attenuation adjustments are applied to each measured half-second spectrum throughout the 10 dB-down period of the airplane overflight. For transport category and turbojet-powered airplanes, the atmospheric attenuation adjustments are applied to each of the 24 third-octave-bands from 50 Hz to 10,000 Hz within each spectrum.
- (3) Layering Requirements: When the atmospheric absorption coefficients vary by more than +/- 1.6 dB per 1000 feet over the sound propagation path between the 10 meter tower and the altitude of the test airplane, the atmosphere between the ground and the airplane is to be layered for evaluation of the atmospheric attenuation of airplane noise. See the Explanation, Supplemental Information, and Procedures listed in this AC under Section A36.2.2.2(d) for further discussion of atmospheric layering requirements.

c. Procedures

- (1) Adjustment Procedures: See A36.9.3.2.1 of this AC for a discussion of procedures (using the equations given in Section A36.7.2) to adjust noise certification data from test to reference conditions accounting for differences in atmospheric sound attenuation.

235. Section A36.8. [Reserved]

236. Section A36.9. Adjustment of Airplane Flight Test Results

237. Section A36.9.1

When certification test conditions are not identical to reference conditions, appropriate adjustments must be made to the measured noise data using the methods described in this section.

a. Explanation

This section specifies methods for adjustment of noise data when test conditions differ from reference conditions.

b. Supplemental Information

- (1) Adjustments to Reference Conditions: Most noise certification tests are conducted during conditions other than the reference conditions. During these tests, the airplane may be at a different altitude (height over the microphone) or deviate laterally from the intended flight path. The engine power, atmospheric conditions, airplane altitude, and/or gross weight might also differ from reference conditions. Therefore,

measured noise data must be adjusted to reference conditions to determine whether compliance with Part 36, Appendix B, certification noise limits may be achieved. Reference 3.a requires that adjustment procedures and analysis methods be reviewed and approved by AEE. The VNTSC checkout procedure (see below) has been implemented to ensure uniformity of data adjustment methods that are proposed by applicants.

- (2) Reference Conditions: Reference conditions are specified under Section B36.7(a)(5).
- (3) Background Noise Adjustments: Adjustments for the effects of background noise on measured airplane sound pressure levels must be performed. Determination of masking must be accomplished before any frequency-dependent adjustments (such as for system frequency response or microphone free-field response). Appendix 3 of the appended ICAO TM presents a background noise adjustment method that represents the international recommended practice. FAA has developed procedures contained in Appendix 3 of this AC to provide the applicant with a more definitive methodology for accounting for the effects of background noise, including some procedural elements not in the ICAO TM Appendix 3. Based on discussions that have occurred with the FAA/JAA harmonization working group addressing transport airplane noise certification standards, it is expected that future work will be proposed under the ICAO Committee on Aviation Environmental Protection to revise the ICAO TM Appendix 3 background noise adjustment method.
- (4) Band-Dropping: FAA policy does not allow the implementation of band-dropping or band-elimination techniques. Third-octave-band sound pressure levels are not to be set to zero, except as it might normally occur as the result of calculations during the noise data evaluation process (for example, during frequency extrapolation of masked high-frequency band levels).
- (5) VNTSC Checkout: Applicants noise data adjustment and analysis methods require FAA approval, which is based on the VNTSC validation. Any changes, including software revisions, firmware upgrades, or instrumentation changes are subject to VNTSC review before they can be used for noise certification evaluations. Program validation should be planned and the required information (see Appendix 2 – Certification Validation package) submitted to the FAA very early in the certification cycle, since VNTSC evaluation and FAA approval may take longer than 18 months.
- (6) Minimum Approach Distance: At the reference approach parameters of 394 feet altitude and –3 degree glide slope, the reference minimum distance equals 394 feet times the cosine of –3, or 393.46 feet between the aircraft ILS antenna and the microphone measuring station.
- (7) High Altitude Test Sites: For test sites at or above 1,200 feet (366 meters), data must be adjusted to account for jet noise suppression due to the difference in the engine jet velocity and jet velocity shear effects resulting from the change in air density. This adjustment is described in Appendix 6 of the appended ICAO TM.

c. Procedures

- (1) Data Adjustments: The applicant is to adjust all measured data to certification reference conditions by FAA-approved procedures. The applicant should submit all proposed data adjustment procedures to the FAA ACO for review and approval. The FAA may require submittal of extensive detailed information about the data adjustment process and analysis methods for evaluation and acceptance. The U.S. Department of Transportation VNTSC acoustics laboratory assists the FAA AEE in the evaluation and approval of applicants' data adjustment and analysis methods.
- (2) VNTSC Evaluations: Appendix 2, VNTSC Certification Validation Package, provides the information and forms that the applicant should use to submit noise, airplane tracking, and meteorological measurement data to the FAA for evaluation and approval of the applicant's noise certification noise certification data adjustment and analysis methods.

- (3) NPD Evaluations: To facilitate data adjustments, many applicants convert measured noise certification test data into a Noise Power Distance (NPD) database as an equivalent procedure. The NPD data base should be constructed utilizing data that are representative of reference conditions. For example, the selected NPD airspeed should be representative of the range of airspeeds for the configurations and gross weights which are anticipated to be used for reference conditions. Similar adjustments can be made to test conditions for distance, airplane altitude, engine power and atmospheric attenuation to create a useful NPD database. Then, when the reference airspeed and other reference conditions are identified and approved, final noise adjustments can easily be made to the NPD database values to obtain reference EPNL values.
- (4) Applicant's Responsibility: The applicant is responsible for
- Making data adjustments in accordance with a FAA approved noise demonstration compliance plan
 - Obtaining FAA review and approval of noise data adjustment and analysis methods
 - Providing FAA with information or data analyses that demonstrate proposed equivalent procedures will yield EPNL values equal to the methodology of Part 36
 - Ensuring version control of all noise data analysis software and informing the cognizant FAA ACO of all revisions.

238. Section A36.9.1.1

Adjustments to the measured noise values must be made using one of the methods described in sections A36.9.3 and A36.9.4 for differences in the following:

- (a) Attenuation of the noise along its path as affected by "inverse square" and atmospheric attenuation***
- (b) Duration of the noise as affected by the distance and the speed of the airplane relative to the measuring point***
- (c) Source noise emitted by the engine as affected by the differences between test and reference engine operating conditions.***
- (d) Airplane/engine source noise as affected by differences between test and reference airspeeds. In addition to the effect on duration, the effects of airspeed on component noise sources must be accounted for as follows: for conventional airplane configurations, when differences between test and reference airspeeds exceed 15 knots (28 km/h) true airspeed, test data and/or analysis approved by the FAA must be used to quantify the effects of the airspeed adjustment on resulting certification noise levels..***

a. Explanation

This section specifies the types of differences between test and reference conditions that require adjustment of measured noise values.

b. Supplemental Information

- (1) Test Atmospheric Conditions: Noise certification tests are rarely, if ever, conducted during atmospheric conditions that comply with reference conditions (i.e., sea level ambient pressure, 77° Fahrenheit and 70 percent relative humidity).
- (2) Sound Propagation: The sound that propagates along the path between an airplane and the noise measurement points is affected by the meteorological conditions of the air through which the sound passes. Temperature and relative humidity affect the atmospheric absorption of transmitted source noise. Noise test data are to be adjusted to reference conditions using an FAA-approved procedure.

- (3) Homogeneous Path: Reference atmospheric conditions along the propagation path are considered homogeneous (uniform in nature and composition). The reference conditions are sea level (pressure altitude), 77° Fahrenheit temperature, a constant 70 percent relative humidity and zero wind.
- (4) Required Adjustments of Noise Values: Measured noise values must be adjusted to the reference ambient temperature and relative humidity conditions specified in Part 36 and to reference airplane position and engine performance conditions. Reference airplane position and engine performance conditions must be derived using FAA-approved airplane performance data at the reference ambient conditions. These adjustments account for the effects of atmospheric absorption, sound propagation distance, airplane speed, and airplane source noise.
- (5) Other Adjustments to Noise Values: Part 36 is intended to produce accurate, repeatable, and comparable reference EPNL values. Some adjustments inherent in the FAA approval of equivalent procedures may also apply to the overall adjustment of noise values from test to reference conditions. These adjustments may account for-
 - i. Airplane flight path altitude, or
 - ii. Airplane flight path climb or descent angle, or
 - iii. Airplane airspeed tolerance that exceeds the ± 3 percent knot limitation during testing, or
 - iv. Extrapolation of adjusted data for an NPD data base, or
 - v. Airplane configurations (or modifications) that differ from the reference airplane, or
 - vi. Background noise levels, or
 - vii. Engine thrust or power setting, or
 - viii. Spectral irregularities, or
 - ix. Cutback power application, or
 - x. Instrument and equipment calibrations, or
 - xi. Pseudotones.
- (6) Manufacturer's Data: Adjustment of noise values from test to reference conditions should be based on FAA-approved manufacturer's data. Manufacturer's data may include-
 - i. Reference flight profiles during take-off with maximum gross weight
 - ii. Flyover, lateral, and approach engine power or thrust settings at reference conditions
 - iii. Engine cutback power requirements at reference flyover conditions
 - iv. Data defining negative runway gradients
 - v. Reference airspeeds during flyover, lateral, and approach maximum gross weights,

c. Procedures

- (1) Applicant's Responsibility: The applicant is responsible for
 - (i) Developing and obtaining FAA approval of noise data including those associated with equivalent procedures
 - (ii) Obtaining FAA approval of noise data adjustment procedures and analysis methods
 - (iii) Applying approved noise data adjustments used to determine reference EPNL values
 - (iv) Documenting adjustment procedures not specifically identified in Part 36.
- (2) FAA's Responsibility: The FAA is to ensure that applicants proposed noise data adjustments are approved, applied in an approved manner, documented, submitted to the FAA, reviewed, and approved prior to acceptance of applicant's certification data.

239. Section A36.9.1.2

The “integrated” method of adjustment, described in section A36.9.4, must be used on takeoff or approach under the following conditions:

(a) When the amount of the adjustment (using the “simplified” method) is greater than 8 dB on flyover, or 4 dB on approach; or

(b) When the resulting final EPNL value on flyover or approach (using the simplified method) is within 1 dB of the limiting noise levels as prescribed in Section B36.5 of this part.

a. Explanation

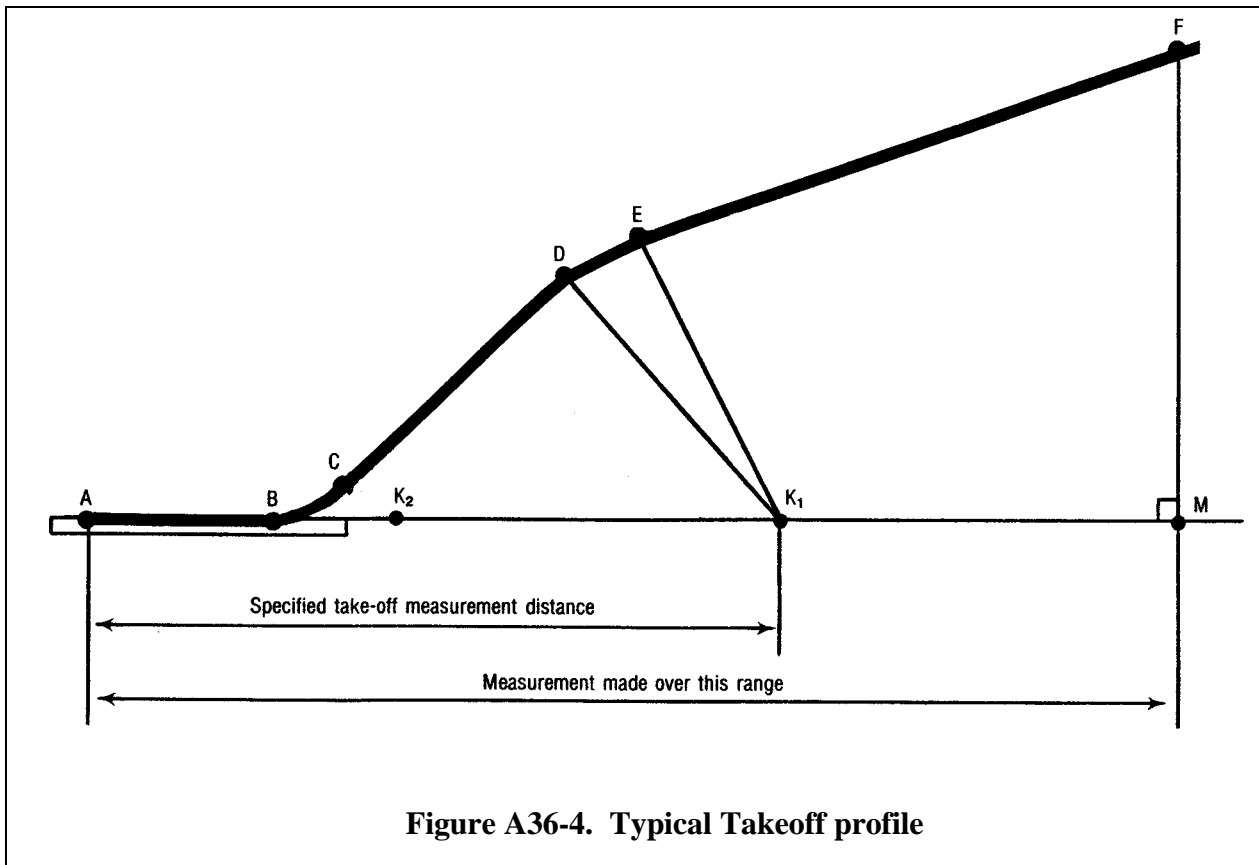
This section specifies criteria for use of the simplified or integrated procedure in determining reference EPNL values for flyover and approach noise measurements.

b. Supplemental Information

- (1) Simplified and Integrated Methods: When testing is conducted at other than reference conditions, noise data adjustments to reference conditions, by one of the following methods are required:
 - (i) The simplified analysis procedure, whereby the PNLTM value of the lateral, flyover, or approach noise measurements is adjusted to reference conditions
 - (ii) The integrated analysis procedure whereby, each half-second spectrum of flyover or approach noise measurements throughout the 10 dB-down period is adjusted to reference conditions. The noise emission angle is kept constant for corresponding test and reference emission times when using this evaluation method.
- (2) Evaluation Test: The following test should be performed to determine whether the simplified or the integrated analysis method is required:
 - (i) Is the final EPNL value for take-off within 1.0 dB of the Appendix B noise limits or was the total noise data adjustment for take-off greater than 8.0 dB?
If no, proceed to (ii). If yes, go to (iv).
 - (ii) Is the final EPNL value for approach within 1.0 dB of the Appendix B noise limit or was the total approach noise data adjustment greater than 4.0 dB?
If no, proceed to (iii). If yes, go to (iv)
 - (iii) The applicant may use the simplified analysis procedure to determine the lateral, flyover or approach EPNL. Apply other appropriate tests to reference noise data adjustments, including those for engine thrust and airplane airspeed corrections.
 - (iv) The applicant is required to use the integrated analysis procedure to determine the flyover or approach EPNL. Apply other appropriate tests to reference noise data adjustments, including engine thrust and airplane airspeed corrections.
- (3) Modern Computers: With today’s modern high-speed computers, most applicants for transport category airplanes utilize only integrated analysis procedures for flyover, lateral, and approach noise measurements.

c. Procedures

- (1) NPD Equivalent Procedures: Applicants that propose the use of NPD databases may be required to use the integrated method as part of an equivalent procedure approval process. Appropriate noise data adjustments from test to reference conditions must be incorporated into the integrated method prior to comparing reference EPNL values to the limits specified in Appendix B.



240. Section A36.9.2 Flight profiles

As described below, flight profiles for both test and reference conditions are defined by their geometry relative to the ground, together with the associated airplane speed relative to the ground, and the associated engine control parameter(s) used for determining the noise emission of the airplane.

241. Section A36.9.2.1 Takeoff Profile

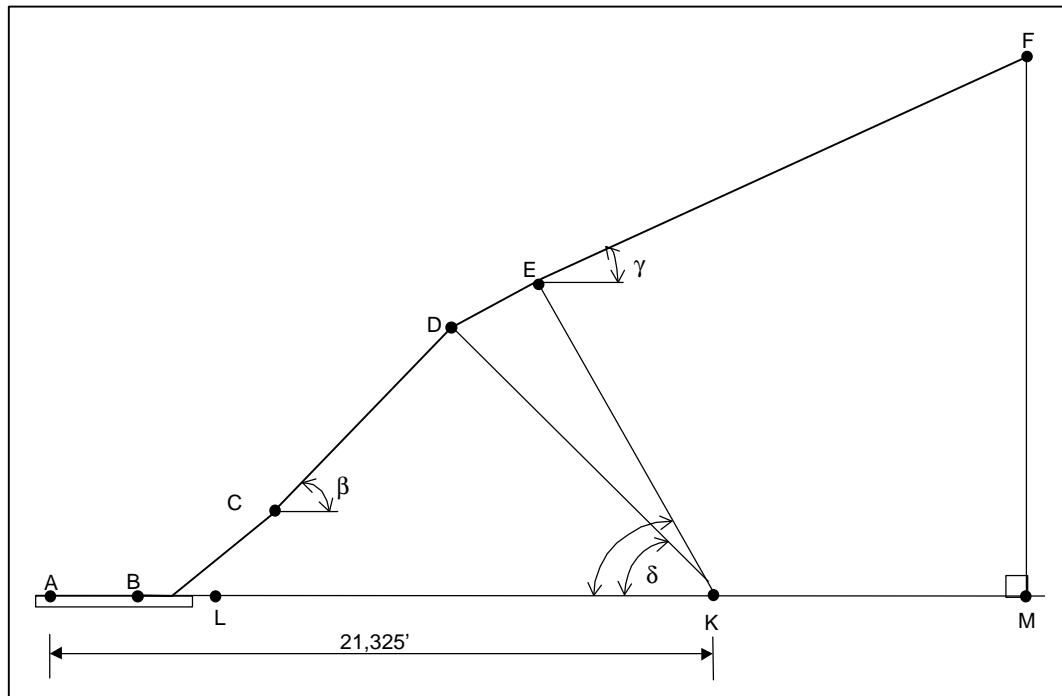
Note: Figure A36-4 illustrates a typical takeoff profile.

(a) The airplane begins the takeoff roll at point A, lifts off at point B and begins its first climb at a constant angle at point C. Where thrust or power (as appropriate) cut-back is used, it is started at point D and completed at point E.

From here, the airplane begins a second climb at a constant angle up to point F, the end of the noise certification takeoff flight path.

(b) Position K_1 is the takeoff noise measuring station and AK_1 is the distance from start of roll to the flyover measuring point. Position K_2 is the lateral noise measuring station, which is located on a line parallel to, and the specified distance from, the runway center line where the noise level during takeoff is greatest.

(c) The distance AF is the distance over which the airplane position is measured and synchronized with the noise measurements, as required by section A36.2.3.2 of this part.



a. Explanation

This section specifies the take-off flight test profiles for determining flyover noise measurements.

b. Supplemental Information

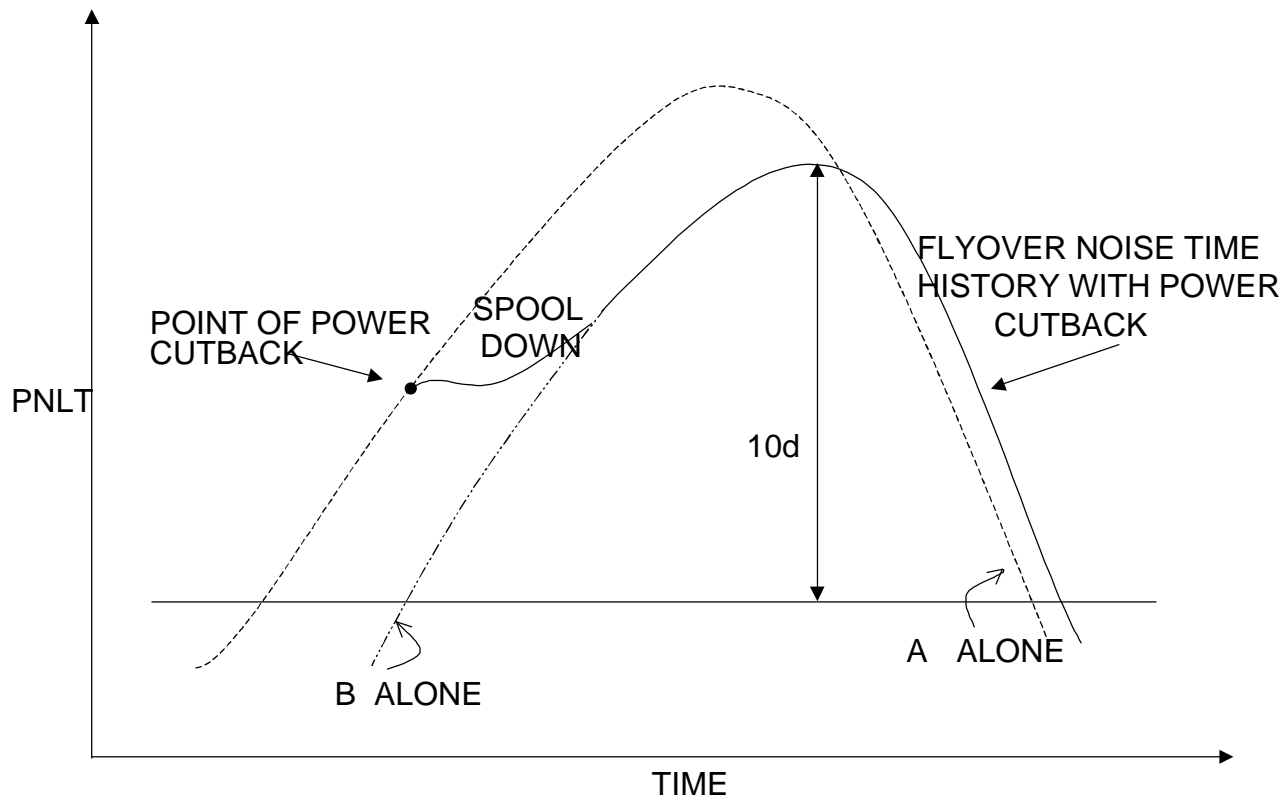
- (1) Take-off Tests: The take-off configuration selected by the applicant must be within the approved airworthiness certification envelope. Special flight crew procedures or aircraft operating procedures are not permitted. The following figures explain the approved takeoff procedures used during noise certification flight testing for transport category and turbojet-powered airplanes.
- (2) Normal Cutback Power Take-offs: Take-offs with cutback power are permitted to be included in the reference flyover noise certification procedure (and in the reference lateral noise certification procedure for tests conducted before March 20, 2002) for subsonic transport category airplanes and turbojet powered airplanes, regardless of category (see Figure A36.4). Maximum average engine take-off power or thrust must be used from the start of take-off roll to the minimum altitude for initiation of cutback power as specified in Section B36.7(b); see the table below. As shown in Figure 2, the initiation of cutback

power may occur at an altitude above the regulatory minimum and may be within the 10 dB-down time noise-measuring period. The minimum cutback power is the greater of: (a) that required to maintain one-engine-inoperative level flight, and (b) that required to maintain 4 percent climb gradient with all engines operating. A stabilized configuration is to be maintained throughout the 10 dB-down period. The power setting may not be adjusted during the 10 dB-down period, therefore a slight decrease in the climb gradient may occur due to the thrust lapse that results from increased altitude during the 10 dB-down period.

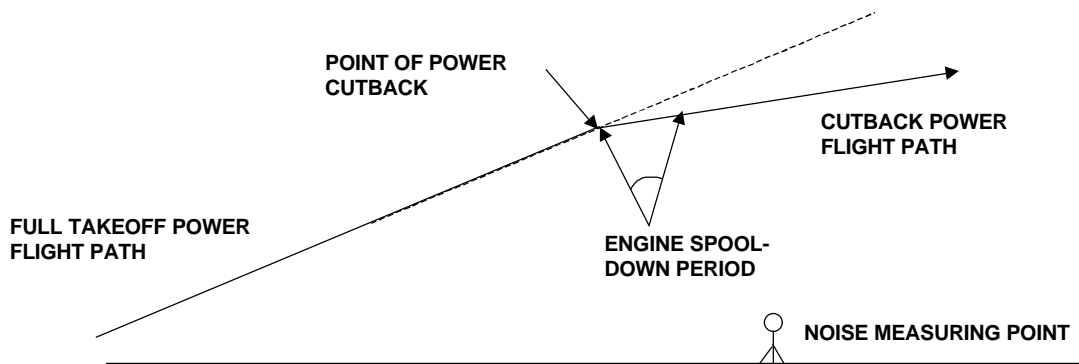
- (3) Minimum Cutback Altitude: During take-off, the engine power may be reduced to cutback power after the minimum cutback altitude has been reached. The minimum cutback altitudes are given below:

Stage	Number of Engines	Bypass Ratio	Minimum Cutback Altitude
1	a. More than 3 turbojet engines	a. All bypass ratios	a. 700 ft (214 m)
	b. 3 or fewer turbojet engines	b. All bypass ratios	b. 1,000 ft (305 m)
	c. Not powered by turbojet engines	c. Not applicable	c. 1,000 ft (305 m)
2	a. More than 3 turbojet engines	a. Less than 2.0	a. 700 ft (214 m)
	b. 3 or fewer turbojet engines	b. Less than 2.0	b. 1,000 ft (305 m)
	c. More than 3 turbojet engines	c. 2.0 or more	c. 689 ft (210 m)
	d. 3 turbojet engines	d. 2.0 or more	d. 853 ft (260 m)
	e. Fewer than 3 turbojet engines	e. 2.0 or more	e. 984 ft (300 m)
	f. Not powered by turbojet engines	f. Not applicable	f. 1,000 ft (305 m)
3	a. More than 3 engines	a. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio.	a. 689 ft (210 m)
	b. 3 engines	b. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio.	b. 853 ft (260 m)
	c. Fewer than 3 engines	c. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio.	c. 984 ft (300 m)

Stage	Number of Engines	Bypass Ratio	Minimum Cutback Altitude
1	a. More than 3 turbojet engines b. 3 or fewer turbojet engines c. Not powered by turbojet engines	a. All bypass ratios b. All bypass ratios c. Not applicable	a. 700 ft (214 m) b. 1,000 ft (305 m) c. 1,000 ft (305 m)
2	a. More than 3 turbojet engines b. 3 or fewer turbojet engines c. More than 3 turbojet engines d. 3 turbojet engines e. Fewer than 3 turbojet engines f. Not powered by turbojet engines	a. Less than 2.0 b. Less than 2.0 c. 2.0 or more d. 2.0 or more e. 2.0 or more f. Not applicable	a. 700 ft (214 m) b. 1,000 ft (305 m) c. 689 ft (210 m) d. 853 ft (260 m) e. 984 ft (300 m) f. 1,000 ft (305 m)
3	a. More than 3 engines b. 3 engines c. Fewer than 3 engines	a. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio. b. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio. c. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio.	a. 689 ft (210 m) b. 853 ft (260 m) c. 984 ft (300 m)



2(A) TAKE-OFF NOISE TIME HISTORY



2(B) TAKE-OFF FLIGHT PATH OVER FLYOVER MEASURING POINT WITH POWER CUTBACK

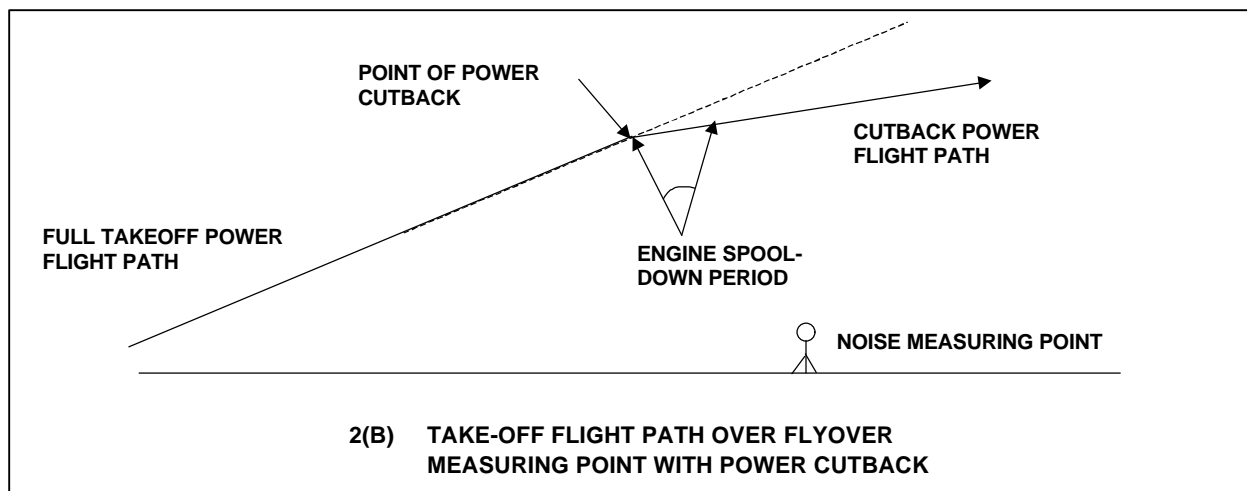
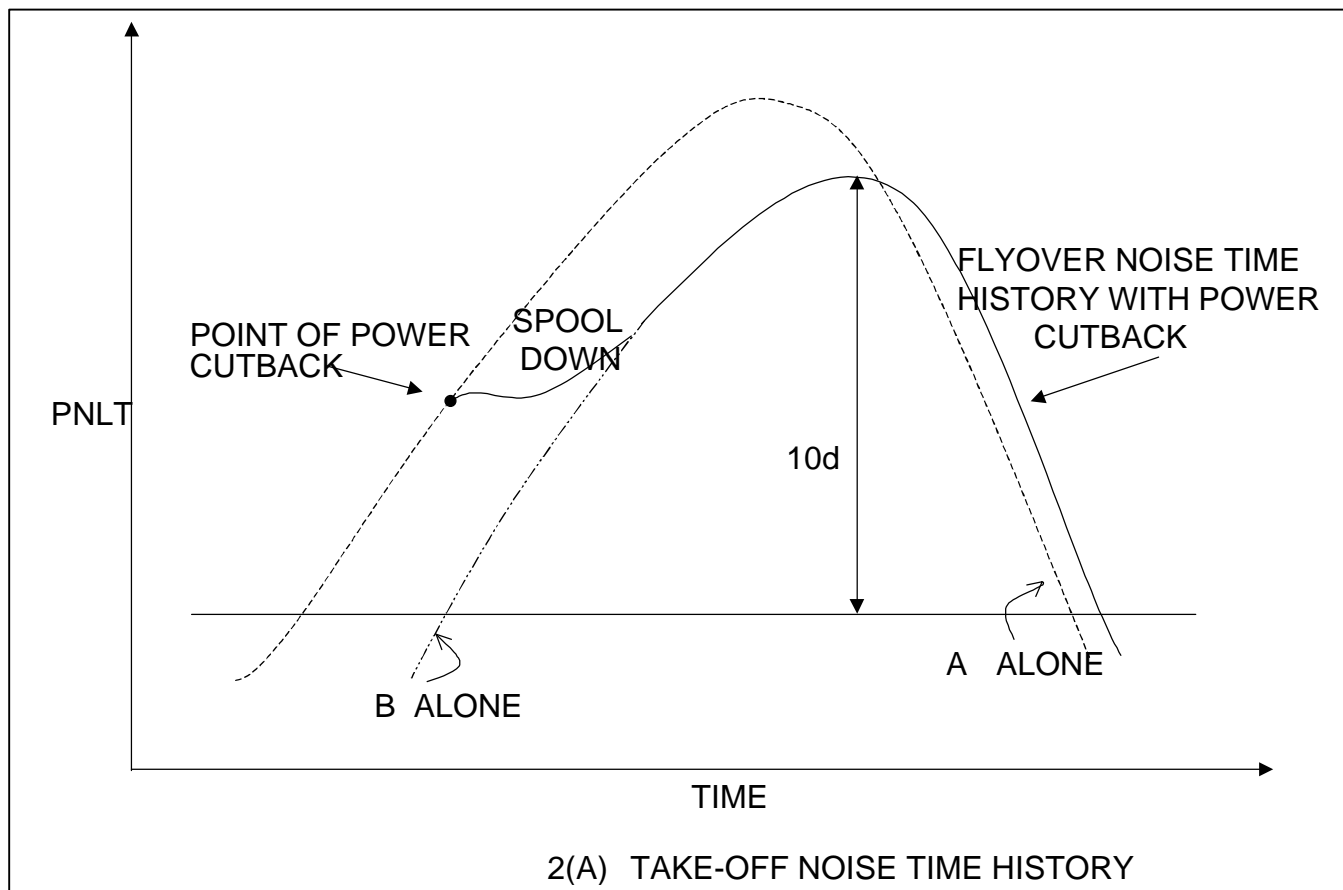


Figure 2: Noise Time History with Cutback Power

- (4) **Full-Power Take-offs:** Full-power take-offs are also permitted to be included in the reference flyover noise certification procedure and are required for the lateral noise certification procedure for tests conducted after March 19, 2002 (see Sections B36.3 and B36.7(b)(3)). Maximum approved take-off power is to be used from the start of roll (Point A) at one end of a runway (Figure 3). Liftoff from the runway is at Point B, after which the landing gear is stowed, and flap positions adjusted. At Point C, the stabilized climb angle and airspeed are achieved while maintaining full take-off power. The airplane continues to climb until sufficiently past (Point F) the microphone(s) to ensure that the 10 dB-down time noise value is

measured. Between Points C and F, the power, flight path, and aircraft configurations are to be kept constant.

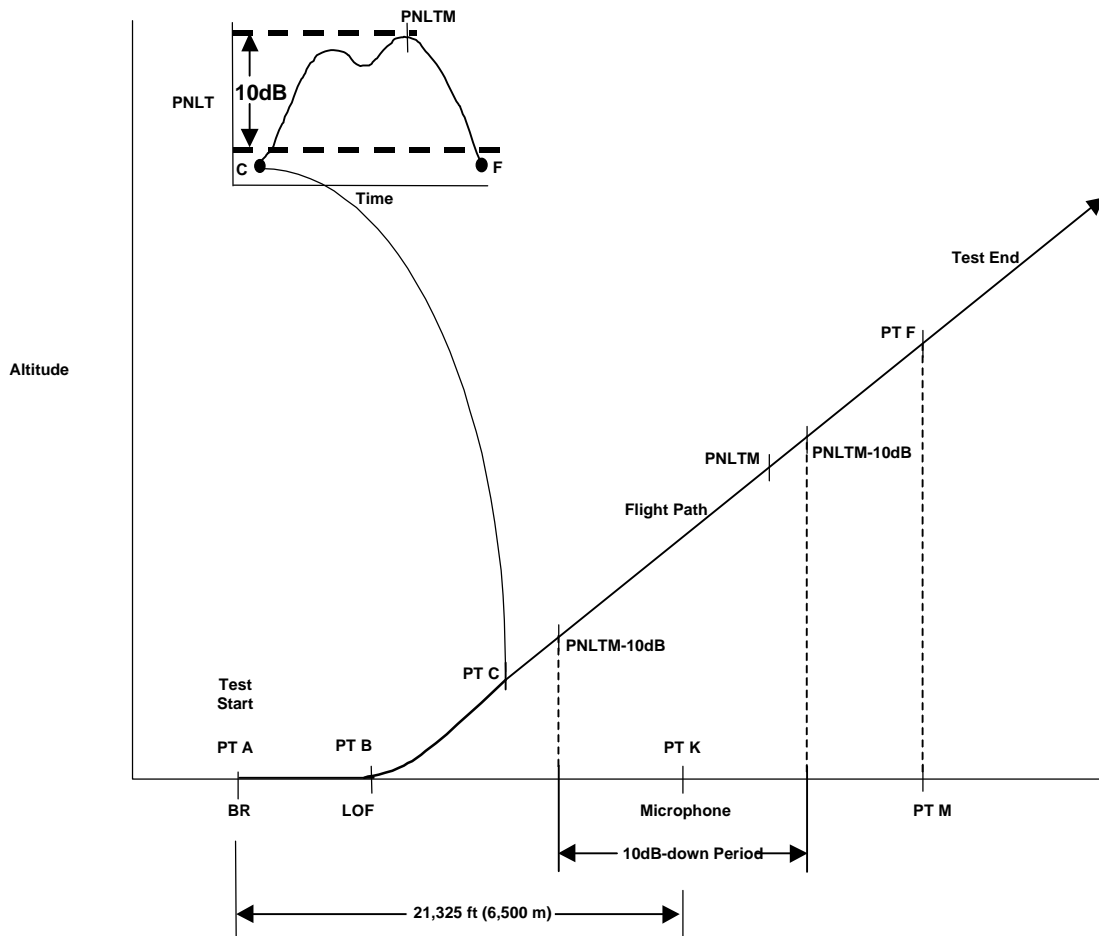
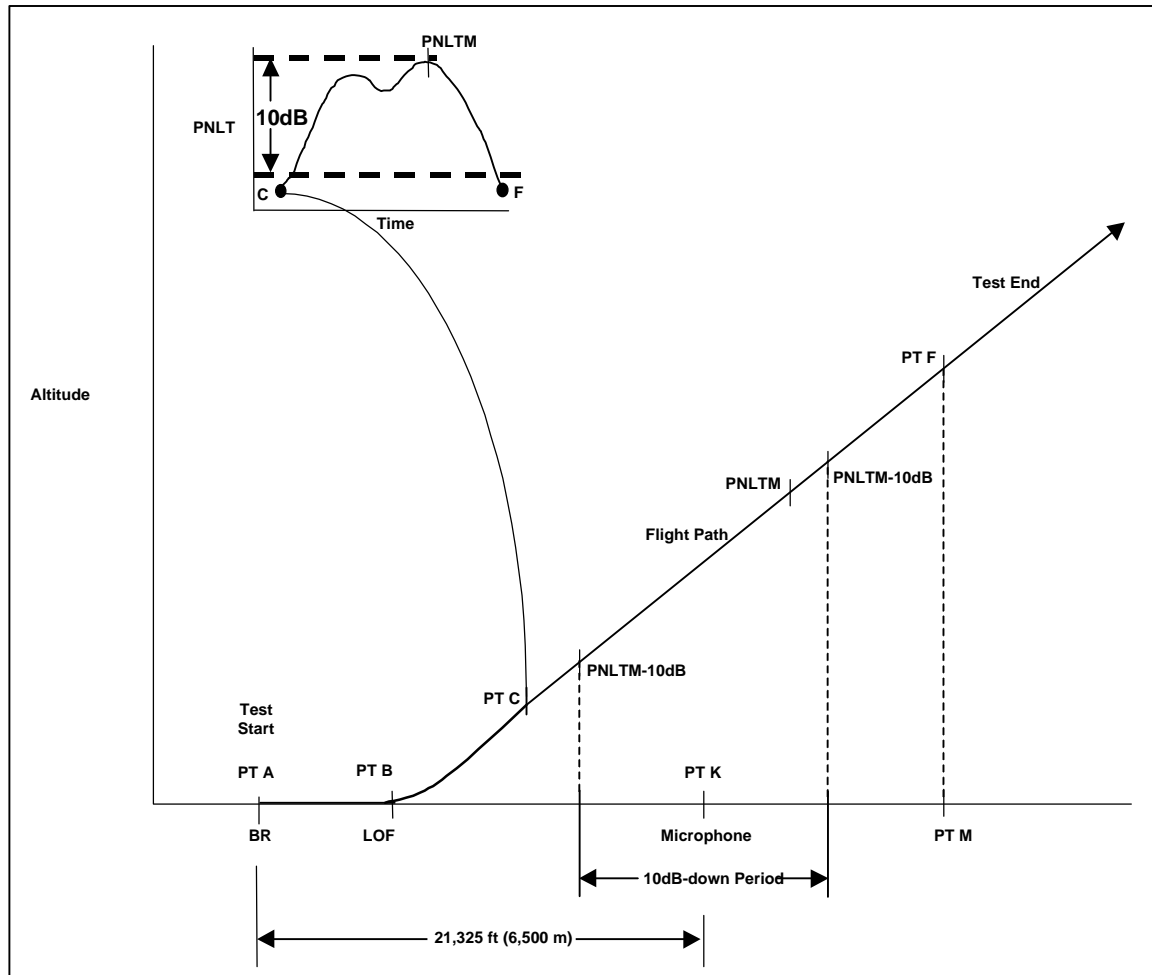


Figure 3: Normal Full Power Take-Off

- (5) Flight Path Intercept Take-off: The flight path intercept method is permitted as an equivalent procedure for take-off noise certification testing (Figure 4). Under this equivalent procedure, noise certification test runs may be conducted with the airplane “intercepting” the relevant portion of the noise certification flight path.



This procedure is used in lieu of performing an actual landing and takeoff for each test run. When using the flight path intercept procedure, the airplane reference flight path, pitch, airspeed, thrust, etc., are to be identical to those that would have existed had the applicant conducted the take-off noise certification test from a static condition on the runway. See section 2.1.1 of the appended ICAO TM.

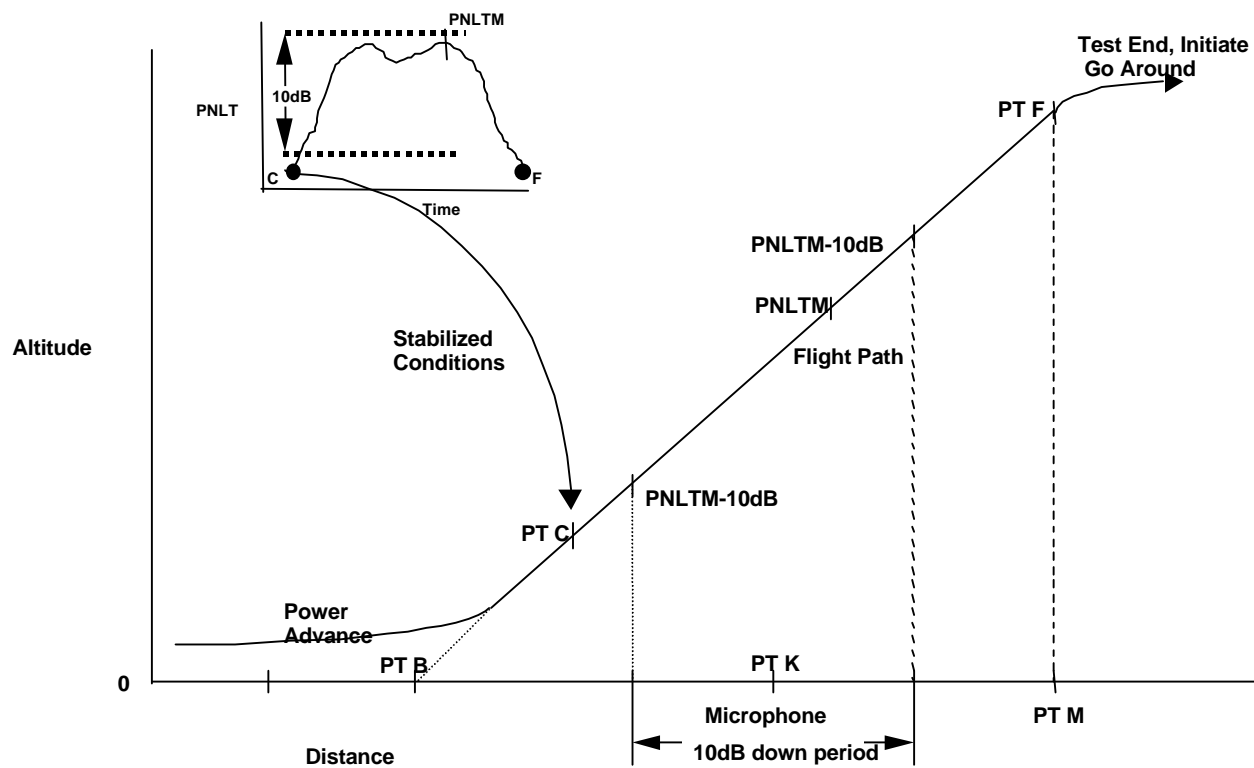
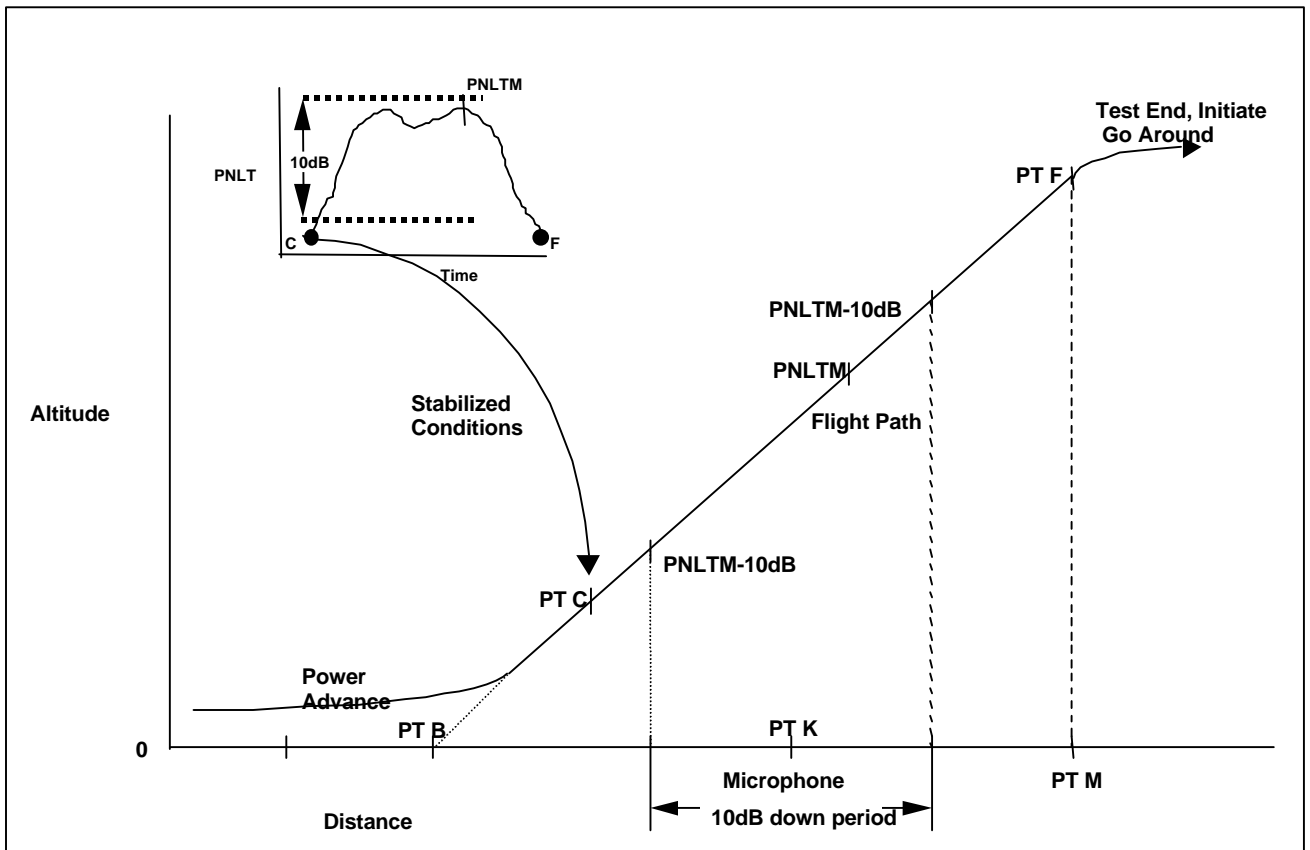


Figure 4: Flight Path Intercept Take-Off



- (6) Flight Path: Approved tolerances (Figure 5) are required for the flight path envelope within which the flight crew can fly between Points C and F (see Supplementary Information under Section A36.2.3.1). Several methods have been devised to assist, and provide direction to the flight crew in order to stay within the required flight path envelope. Indicators located in the airplane cockpit can provide flight path direction and indicate deviations from the extended runway centerline. Transmissions from the airplane position-indicating system (e.g., microwave position system, precision DMU, or DGPS) can also provide useful inputs.

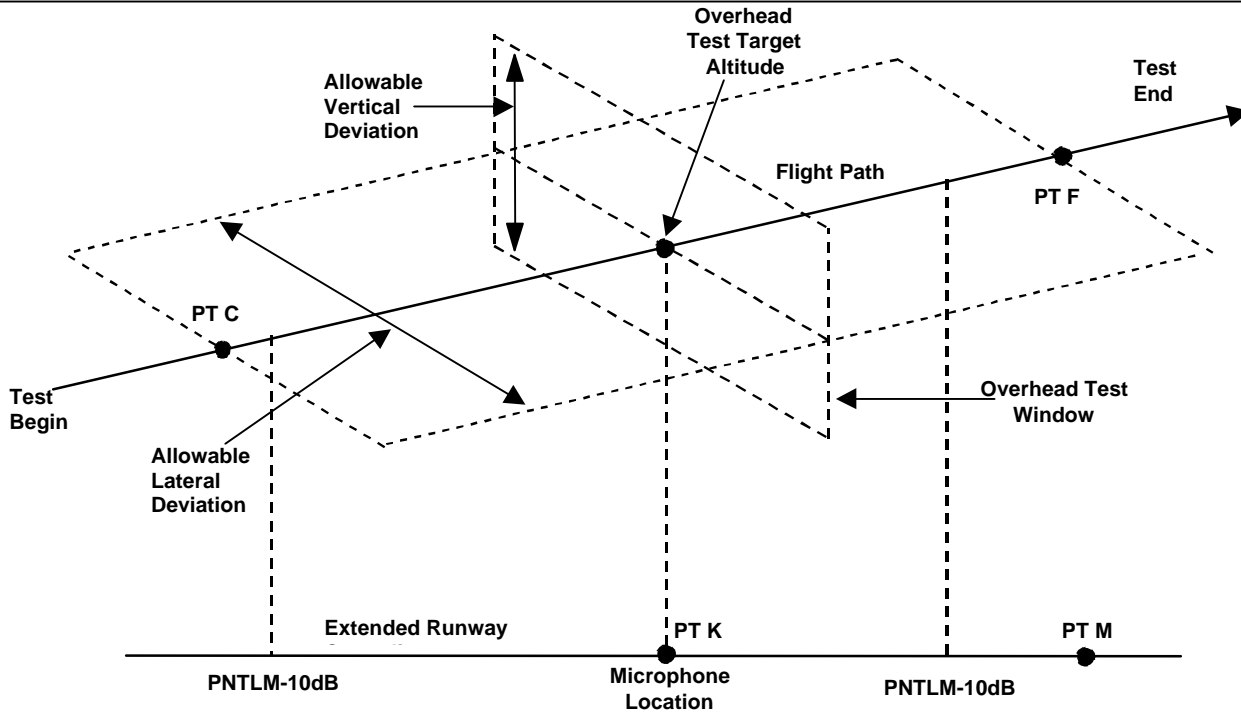
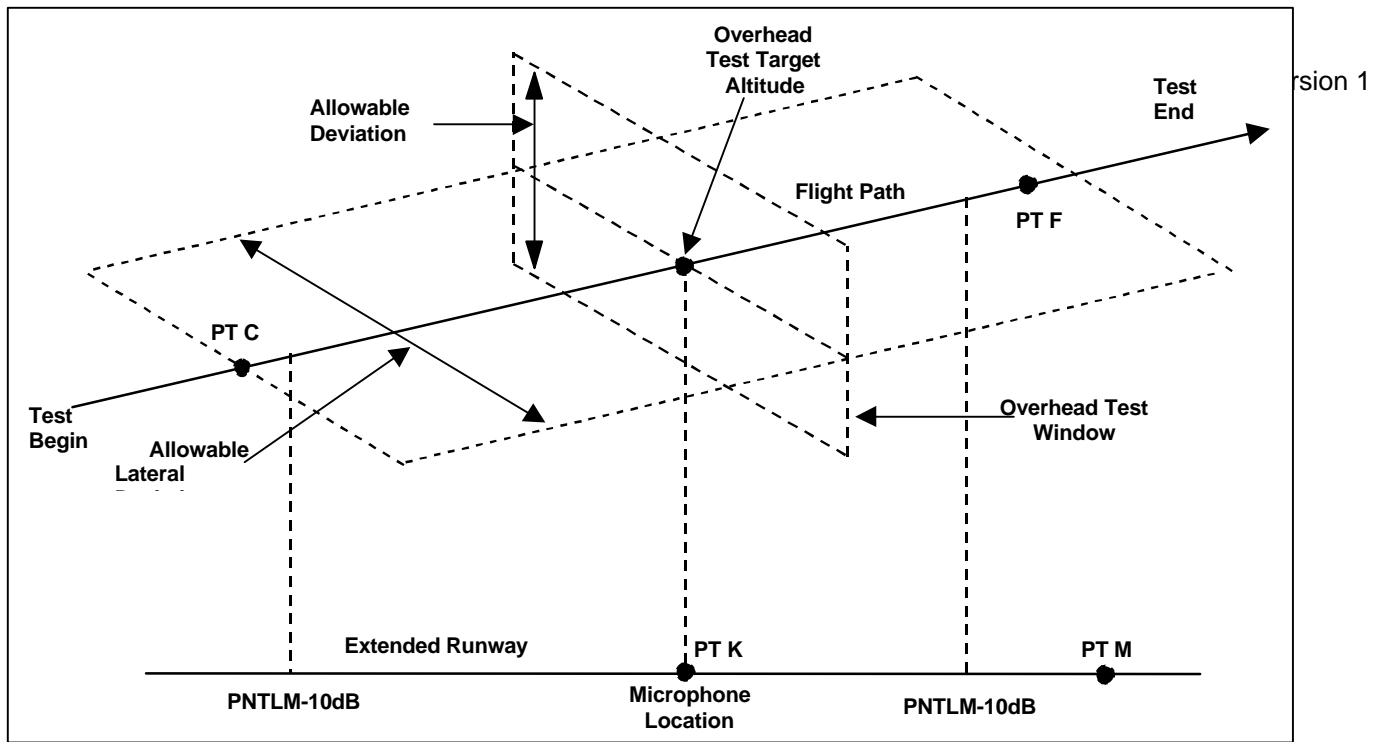


Figure 5: Take-Off Flight Path

c. Procedures

- (1) Target Test Conditions: Target test conditions are established for each noise measurement. These target conditions define the flight procedure, aerodynamic configuration to be selected, airplane weight, engine

thrust, airspeed, and, at the closest point of approach to the noise measurement point, airplane altitude. Regarding choice of target airspeeds and variation in test weights, the possible combinations of these test elements may affect the airplane angle-of-attack or airplane altitude and therefore possibly the airplane noise generation or propagation geometry. See section 2.1.2.1 of the appended ICAO TM for guidance on the choice of target airspeeds and variation in test weights.

- (2) Simulated Cutback Evaluation: When a power cutback, as permitted under section B36.7(b), is used in conjunction with establishing the flyover noise certification level (or lateral noise certification level for tests conducted before March 20, 2002, a commonly used equivalent procedure allows for the noise certification level to be determined through the coupling of the NPD database with the approved engine spool-down data. As long as the minimum cutback height requirements specified in section B36.7(b)(1) are met, the cutback initiation height may be selected to ensure stabilized cutback power conditions before the initial 10 dB-down point. As discussed in Section 2.2.1.2 of the appended ICAO TM, this procedure can be implemented using constant stabilized cutback power throughout the 10 dB-down period. Flyover noise levels with power cutback may also be established from the merging of PNLT versus time measurements obtained during constant power operations. The 10 dB-down period may contain portions of both the full power and cutback power noise time histories. Section 2.2.1.1 of the appended ICAO TM describes the establishment of the flyover noise certification level when the 10-dB down PNLT noise time history contains portions of both full power and cutback power. The FAA should witness and approve all engine spool-down testing. See Section B36.7(b)(1) for additional information regarding engine spool-down testing.
- (3) Flight Test Procedures: Before the start of noise testing the FAA and the applicant must approve flight path tolerances (see Supplemental Information under Section A36.2.3.1). Between Points C and F, the engine power, airplane flight path, and aerodynamic configuration should be kept constant during each approved certification flight test (except when take-offs with cutback power are being demonstrated).
- (4) Invalid Test Data: Noise measurements obtained when the airplane flies outside the approved flight path envelope between Points C and F (Figure 5) during a noise certification test are considered invalid, and the noise measurement is to be repeated.

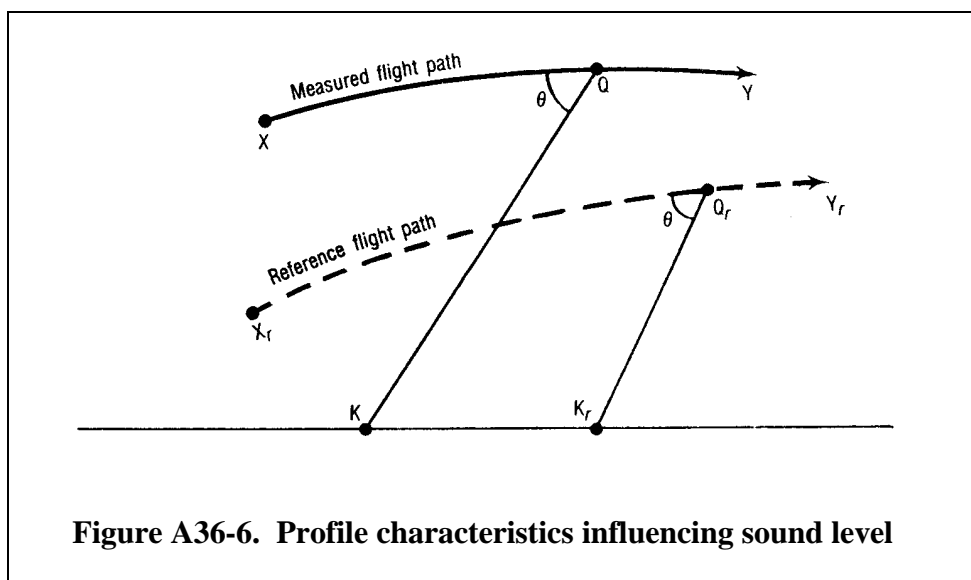
242. Section A36.9.2.2 Approach Profile

Note. - Figure A36-5 illustrates a typical approach profile.

(a) The airplane begins its noise certification approach flight path at point G and touches down on the runway at point J, at a distance OJ from the runway threshold.

(b) Position K_3 is the approach noise measuring station and K_3O is the distance from the approach noise measurement point to the runway threshold.

(c) The distance GI is the distance over which the airplane position is measured and synchronized with the noise measurements, as required by section A36.2.3.2 of this part. The airplane reference point for approach measurements is the instrument landing system (ILS) antenna.

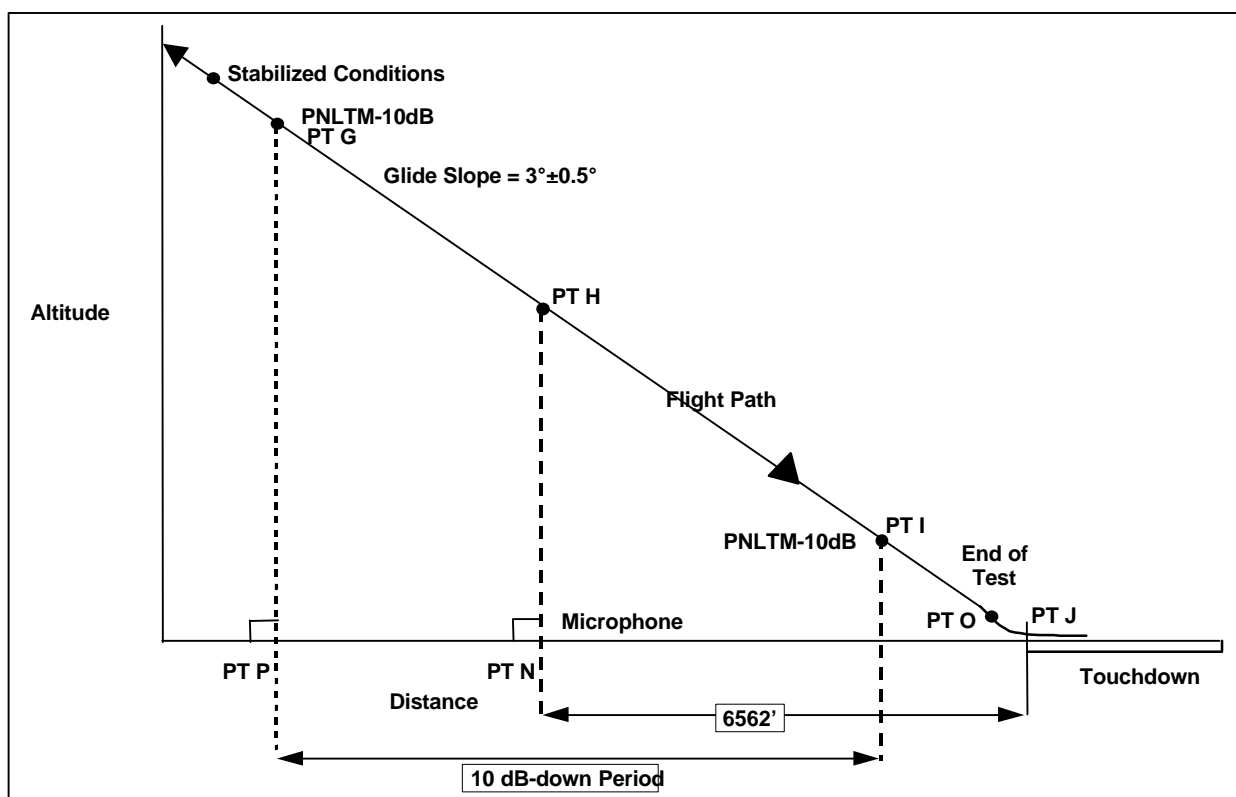


a. Explanation

This section provides an illustration and explanation of the required approach flight path.

b. Supplemental Information

- (1) Approach Tests: Figures 6 and 7 depict the types of approved approach flight procedures used during noise certification testing for transport category and turbojet-powered airplanes. The approach angle (steady glide angle) for this condition is $3^\circ \pm 0.5^\circ$, and the target airplane height vertically over the noise measurement point is 394 feet. Figure 8 indicates the type of approach flight test path deviations that can influence the measured noise levels. Maximum PNLT may occur before or after the approach noise measurement point.
- (2) Normal Approach Flight Tests: Part 36 specifies a full landing following each approach noise measurement (Figure 6). This type of flight test is less efficient than the flight intercept equivalent procedure that is used by most noise certification applicants. See section 2.1.1 of the appended ICAO TM for more guidance on the use of the flight intercept procedure.



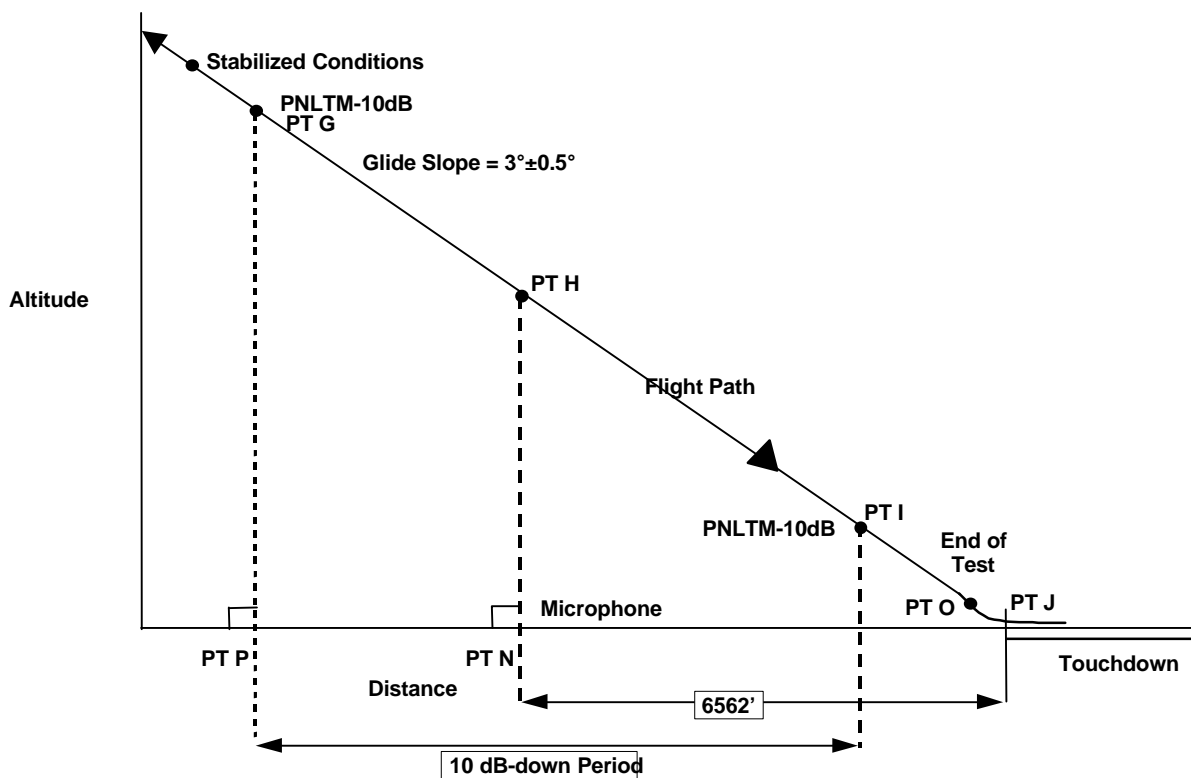


Figure 6: Approach With Full Landing

- (3) Flight Path Intercept Approaches: During the flight path intercept method, the airplane does not land but, following the determination that the 10 dB-down time requirements have been satisfied, initiates a go-around maneuver and returns to the in-flight setup location for the next test condition (Figure 7). Most applicants use the flight path intercept method for approach flight testing. This procedure permits the applicant to remain flying during acceptable atmospheric conditions without the delays associated with landings and take-offs.

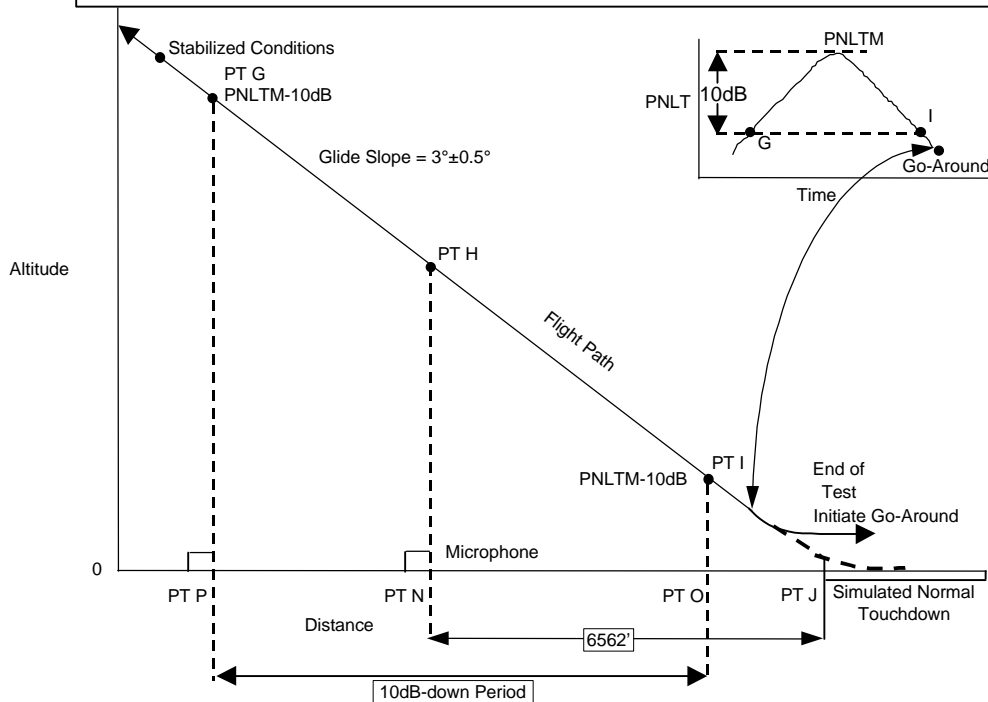
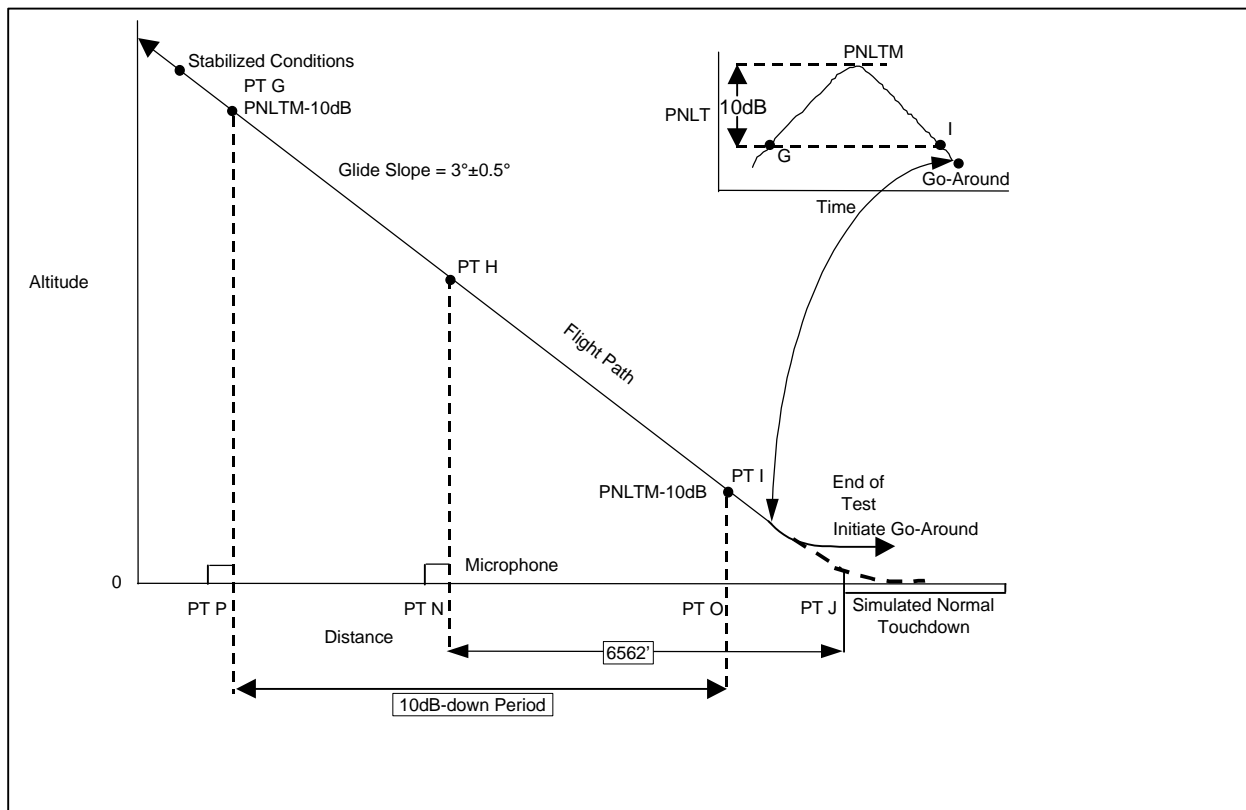
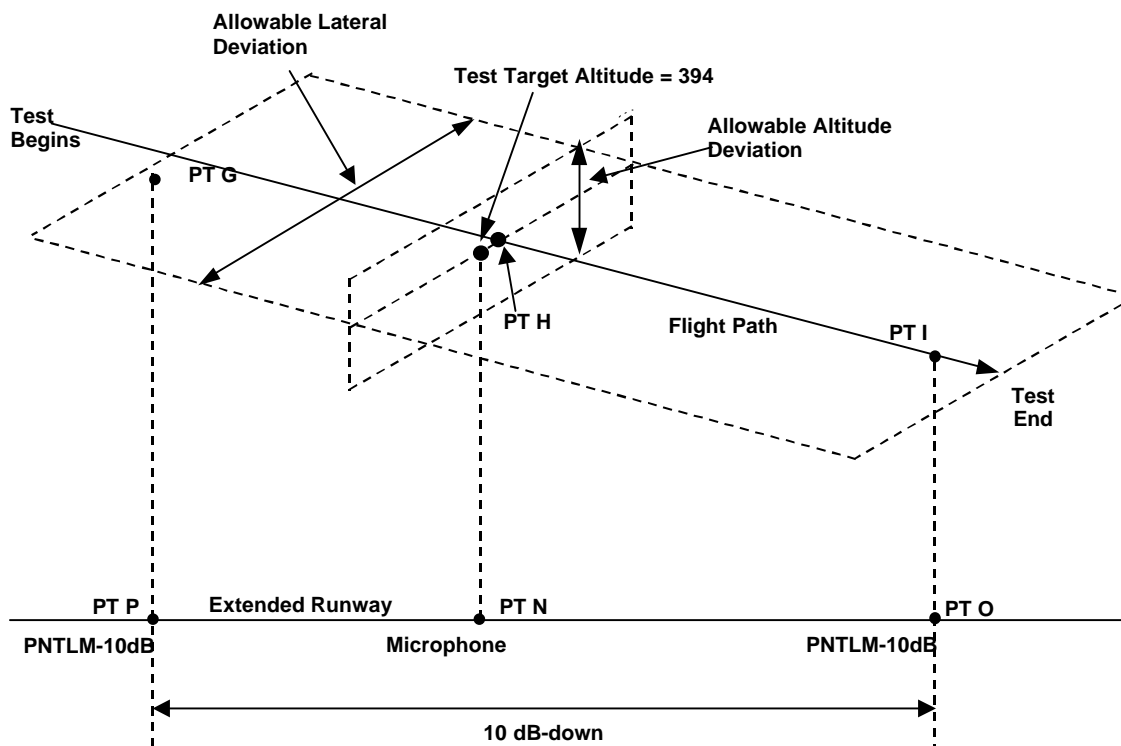


Figure 7: Flight Path Intercept Approach

- (4) Flight Path Deviations: Approved altitude and centerline deviations along the extended runway approach flight path (Figure 8) define an approved flight path envelope within which the flight crew can fly between Points G and I (see Supplemental Information under Section A36.2.3.1). Since the flight crew has a clear view of the airport runway during approach conditions, it is normal for the crew to consistently fly within the approved flight path envelope. Therefore, the approved centerline and altitude deviations for approach conditions may be smaller than during take-off conditions.



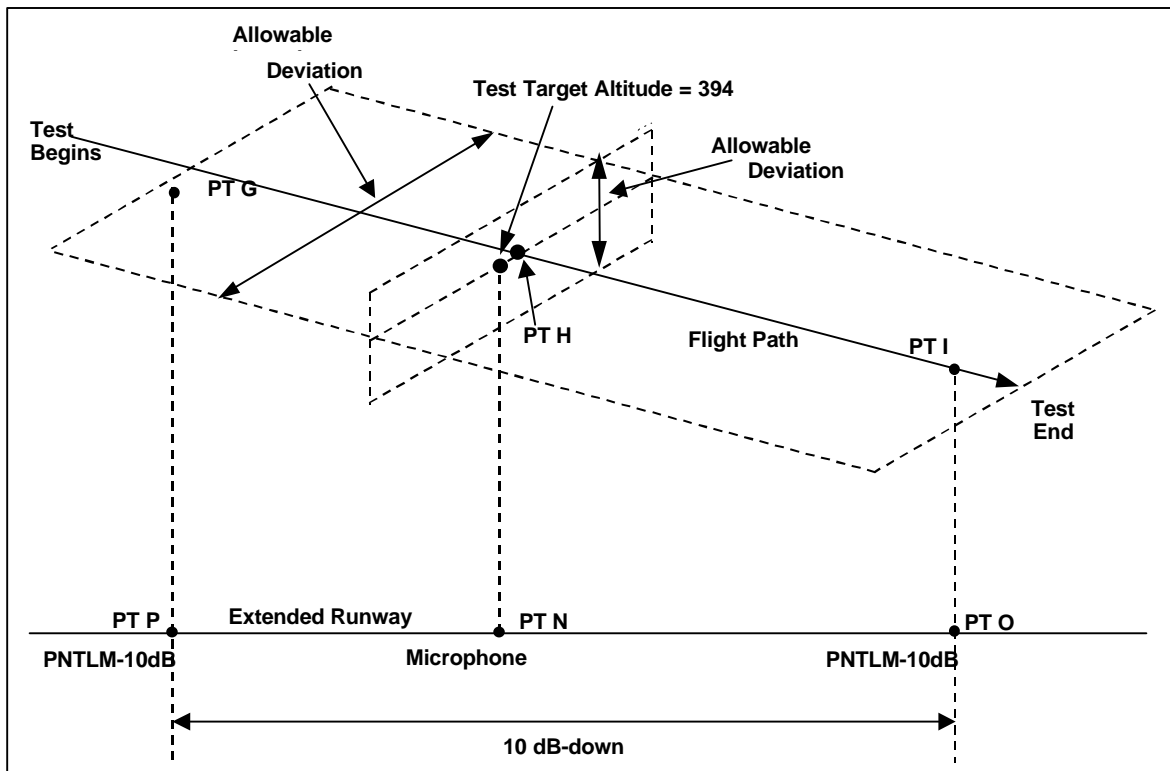


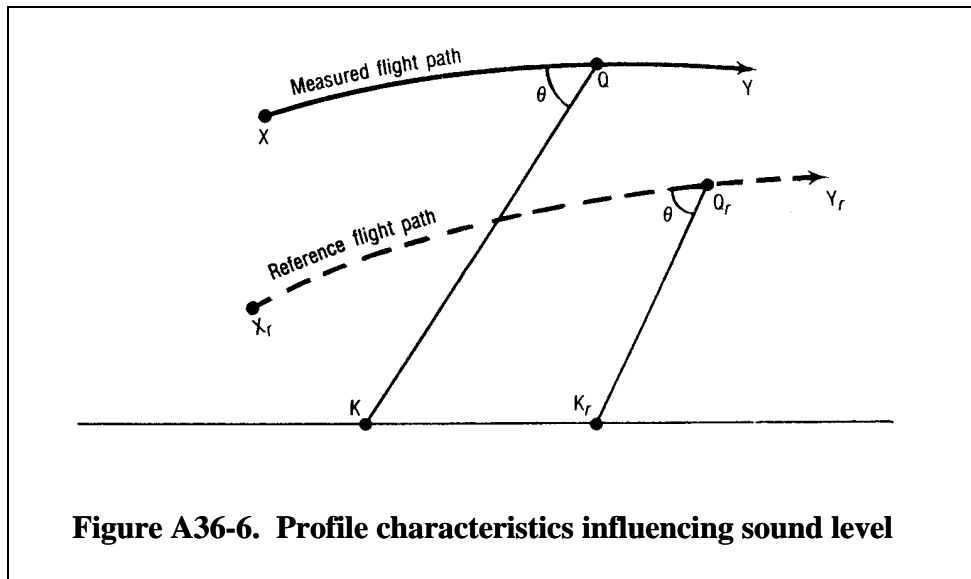
Figure 8: Approach Flight Path Deviations

c. Procedures

- (1) Noise-Power-Distance Database: By developing an approach noise-power-distance database, the applicant can obtain noise certification data to cover a range of airplane weights and engine power settings. The NPD method is an equivalent procedure and must be approved by the FAA prior to its use. In developing an NPD database, noise data may be obtained with a series of different engine thrust settings down to in-flight idle power. The NPD database can then be used to determine reference condition approach noise level. Stabilized power (Point G) is set before the initial 10 dB-down point and maintained until the subsequent 10 dB-down point has passed (Point I). The applicant should take care to obtain enough thrust settings to permit a second or third order curve fit through the generalized data, and to define data shifts that may be caused by engine internal compressor bleed operations. In creating an NPD database, it will not be possible to maintain all of the constant constraints of weight, airspeed, power, configuration, glide path, and height over the microphone. The critical test parameters to be maintained are constant power and configuration during the test condition. The glide angle during the NPD test shall be that which results from the aircraft conditions (i.e., weight, configuration, airspeed, and engine power). See section 2.1.2 of the appended ICAO TM.
- (2) Target Test Conditions: Target test conditions should be established for each noise test flyover. These define the selected aerodynamic configuration, system operation, airplane weight, flight procedure (such as complete landings or flight path intercepts), initiation altitude, power, and airspeed during each overflight. The applicant is required to select the approved airworthiness configuration for the approach noise certification that produces the loudest noise (i.e., the most critical from the standpoint of noise). Airspeed is generally held to within ± 3.0 percent of the average airspeed during the 10 dB-down measuring period. The aerodynamic configuration (e.g., flap setting, A/C, and/or APU system operation) is to remain constant during the noise measurement period. Airspeed variations are measured in indicated airspeed determined by the pilot's airspeed indicator.
- (3) Engine Idle Trim: For engines where the idle trim may affect the intercompressor bleed valve schedule during the approach condition, the engine in-flight idle trim should be adjusted to the highest engine rpm setting permitted by the engine manufacturer and consistent with airworthiness requirements. The engine may also provide ground idle trim adjustment, but the trim that needs adjustment is that which is operable during flight. In-flight idle trim may be adjusted to improve engine acceleration characteristics to satisfy

airworthiness compliance (e.g., with Part 25.119). The higher idle trim will cause the highest engine rpm (idle thrust), which results in a greater airplane angle of attack, and will result in the loudest approach noise required for certification. The applicant is to make those adjustments necessary to satisfy the airworthiness regulations. This idle trim adjustment may affect the performance or evaluation of approach NPD testing.

- (4) Internal Compressor Bleed Adjustment: The internal compressor bleed operation (sometimes referred to as the surge bleed valve (SBV) operation) should be adjusted within the engine manufacturer's specification to represent reference conditions as closely as possible. Most turbojet engines are equipped with internal compressor bleed systems. The internal compressor bleed operates to reduce the possibility of internal engine surges during rapid throttle movements. Some turbojet engines have overboard bleed systems that are very loud. These systems normally operate above in-flight idle and do not present a problem unless the applicant chooses to prepare an NPD database and the power settings higher than in-flight idle may be affected by the internal compressor bleed operation. The applicant is responsible for indicating that the internal compressor bleed operation does not affect the reference EPNL values during noise certification reference conditions.
- (5) Flight Test Procedures: The approved approach flight path altitude and centerline deviations identify the tolerances of the flight path that are agreed on by the FAA and the applicant before the start of noise certification flight testing. Between Points G and I (see Figure 8), the engine power, approach angle, airspeed, system operational configuration and aerodynamic configuration should be kept constant throughout the noise measurement (10 dB-down points). The flight path deviations may be smaller for approach conditions than for take-off conditions, since the flight crew can better observe the ground, measuring location, and runway (or extended runway) and has better control over the airplane during the overflight.
- (6) Approach Test Airspeed Procedures: The airspeed requirement for subsonic airplanes is $V_{REF} + 10$ knots. This airspeed is kept constant (within ± 3.0 percent) between the approach measuring points (Points G and I in Figure 8). All test conditions should be conducted within 15 knots of the reference approach airspeed.
- (7) Invalid Test Data: Noise measurements obtained when the aircraft flies outside the approved flight path envelope between Points G and I are invalid, and the noise measurement must be repeated.
- (8) Flight Path Intercept Procedures: Most, if not all, current applicants use the flight path intercept method of testing. (see Figure 7). The airplane approaches the test area at a high altitude, reduces to the desired power setting at the predetermined configuration and maintains a 3-glide slope. When all conditions are stabilized, the airplane should be at a position (Point G, or condition "on") before the first 10 dB-down point. Flight conditions are kept constant past overhead, past PNLTM, and until the ground test crews have identified a point (Point I or condition "off") after the last 10-dB-down point. A go-around is initiated before to runway touchdown in order to continue flight and setup for the next noise measurement.



243. Section A36.9.3 Simplified method of adjustment.

244. Section A36.9.3.1 General

General. *As described below, the simplified adjustment method consists of applying adjustments (to the EPNL, which is calculated from the measured data) for the differences between measured and reference conditions at the moment of PNLTM.*

a. Explanation

This section specifies a methodology, known as the simplified method of adjustment, for adjusting noise data from test to reference conditions. Use of this method for adjustment of take-off and approach noise data is limited by the criteria given in Section A36.9.1.2 (a) and (b).

245. Section A36.9.3.2 Adjustments to PNL and PNLT.

(a) *The portions of the test flight path and the reference flight path described below, and illustrated in Figure A36-6, include the noise time history that is relevant to the calculation of flyover and approach EPNL. In figure A36-6:*

(1) *XY represents the portion of the measured flight path that includes the noise time history relevant to the calculation of flyover and approach EPNL; X_rY_r represents the corresponding portion of the reference flight path.*

(2) *Q represents the airplane's position on the measured flight path at which the noise was emitted and observed as PNLTM at the noise measuring station K. Q_r is the corresponding position on the reference flight path, and K_r the reference measuring station. QK and Q_rK_r are, respectively, the measured and reference noise propagation paths, Q_r being determined from the assumption that QK and Q_rK_r form the same angle θ with their respective flight paths.*

The portions of the test flight path and the reference flight path described below, and illustrated in Figure A36-7(a) and (b), include the noise time history that is relevant to the calculation of Lateral EPNL.

(1) In figure A36-7(a), XY represents the portion of the measured flight path that includes the noise time history that is relevant to the calculation of Lateral EPNL; in figure A36-7(b), $X_r Y_r$ represents the corresponding portion of the reference flight path. For the Lateral noise measurement, sound propagation is affected not only by inverse square and atmospheric attenuation, but also by ground absorption and reflection effects which depend mainly on the angle γ .

(2) Q represents the airplane position on the measured flight path at which the noise was emitted and observed as PNL_{TM} at the noise measuring station K. Q_r is the corresponding position on the reference flight path, and K_r the reference measuring station. QK and $Q_r K_r$ are, respectively, the measured and reference noise propagation paths. In this case K_r is only specified as being on a particular Lateral line; K_r and Q_r are therefore determined from the assumptions that QK and $Q_r K_r$:

- (i) Form the same angle α with their respective flight paths; and**
- (ii) Form the same angle γ with the ground.**

a. Explanation

This section specifies the portions of flyover, lateral, and approach measured and reference flight paths that are relevant to the calculation of EPNL, and shows the symbols and geometry of the respective airplane positions, resulting noise angles, and sound propagation paths.

246. Section A36.9.3.2.1

The one-third octave band levels $SPL(i)$ comprising PNL (the PNL at the moment of PNL_{TM} observed at K) must be adjusted to reference levels $SPL(i)_r$ as follows:

A36.9.3.2.1(a) For calculations using the English System of Units:

$$SPL(i)_r = SPL(i) + 0.001[\mathbf{a}(i) - \mathbf{a}(i)_0]QK \\ + 0.001\mathbf{a}(i)_0(QK - Q_r K_r) \\ + 20\log(QK/Q_r K_r)$$

In this expression,

- (1) the term $0.001[\mathbf{a}(i) - \mathbf{a}(i)_0]QK$ is the adjustment for the effect of the change in sound attenuation coefficient, and $\mathbf{a}(i)$ and $\mathbf{a}(i)_0$ are the coefficients for the test and reference atmospheric conditions respectively, determined under section A36.7 of this appendix;**
- (2) the term $0.001\mathbf{a}(i)_0(QK - Q_r K_r)$ is the adjustment for the effect of the change in the noise path length on the sound attenuation;**
- (3) the term $20\log(QK/Q_r K_r)$ is the adjustment for the effect of the change in the noise path length due to the "inverse square" law;**
- (4) QK and $Q_r K_r$ are measured in feet and $\mathbf{a}(i)$ and $\mathbf{a}(i)_0$ are expressed in dB/1000 ft.**

A36.9.3.2.1(b) For calculations using the International System of Units:

$$\begin{aligned} \text{SPL}(i)_r &= \text{SPL}(i) + 0.01[\mathbf{a}(i) - \mathbf{a}(i)_0]QK \\ &+ 0.01\mathbf{a}(i)_0(QK - Q_r K_r) \\ &+ 20\log(QK/Q_r K_r) \end{aligned}$$

In this expression,

- (1) the term $0.01[\mathbf{a}(i) - \mathbf{a}(i)_0]QK$ is the adjustment for the effect of the change in sound attenuation coefficient, and $\mathbf{a}(i)$ and $\mathbf{a}(i)_0$ are the coefficients for the test and reference atmospheric conditions respectively, determined under section A36.7 of this appendix;***
- (2) the term $0.01\mathbf{a}(i)_0(QK - Q_r K_r)$ is the adjustment for the effect of the change in the noise path length on the sound attenuation;***
- (3) the term $20\log(QK/Q_r K_r)$ is the adjustment for the effect of the change in the noise path length due to the inverse square law;***
- (4) QK and $Q_r K_r$ are measured in meters and $\mathbf{a}(i)$ and $\mathbf{a}(i)_0$ are expressed in dB/100 m.***

a. Explanation

This section specifies the required adjustments to flyover, lateral, and approach sound pressure levels to account for the difference between test and reference conditions.

b. Supplemental Information

- (1) Test and Reference Conditions: Most noise certification testing is accomplished at other than reference conditions (see Section A36.5.3.1). When testing is conducted at conditions other than reference conditions, appropriate and approved adjustments are to be made to the measured noise data.
- (2) Noise Emission Angles: The noise emission angle between the noise propagation path and the airplane flight paths must be equal for both test and reference evaluations.
 - (i) For the simplified method, the time at which PNLTM occurs during the noise measurement, this defines the test noise emission angle. This angle will then define the location along the reference flight path where the reference PNLTM occurs.

c. Procedures:

- (1) Calculation of Atmospheric Absorption Coefficients: When using a “layered” atmosphere, the average absorption coefficient, $\alpha(i)$, for each one-third octave band must be calculated by apportioning the coefficient values of the individual layers. The goal is to account for each layer’s contribution to the atmospheric absorption of sound propagation through the layered atmosphere. Since propagation is assumed to occur in a straight line between the aircraft and the microphone, and since the proportion of the propagation distance through each layer is constant to the vertical distance through the layer, the average absorption through the layers can be determined using the aircraft altitude.

To determine the proper proportion of each layer’s coefficient in the average value, first determine the aircraft altitude above the microphone. (In this case, at the time of PNLTM.) Then, determine the effective depth of each layer; that is, the vertical distance that the sound propagates through the layer. Next, for each layer, multiply the layer’s absorption coefficient by the ratio of the layer’s effective depth to the aircraft altitude above the microphone, and sum the resulting values.

Note that the full depth of the lowest (and in some cases, the highest) layer is not utilized. The depth of the lowest layer must have the microphone height subtracted. (I.e., for a nominal 100-foot layer, only 96 feet of vertical depth would affect the sound propagation to the four foot high microphone.) Also, unless the aircraft altitude coincides with the upper boundary of one of the layers, the layer containing the aircraft altitude will have only a partial effect on sound propagation.

- (2) Example: Using the same layered atmospheric data presented under Section A36.2.2.3 of this AC, and assuming an altitude above the ground at the microphone station (In this case, at the time of PNLTM,) of 394 feet, the average atmospheric absorption coefficient for the 3150 Hz band would be 16.795 dB per 1000 feet.

Layer Height, ft.	α (3150), dB/1000 ft.	Effective Layer Depth, ft.
Ground to 100	17.55	96 (100 minus 4)
100 to 200	17.15	100
200 to 300	16.65	100
300 to 400	15.80	94 (394 minus 300)

Table 4: Example - Effective Layer Depth

The effective depth of the lowest layer is 96 feet, since the layer is 100 feet high and the microphone extends four feet into the layer. The effective depths of the 2nd and 3rd layers are 100 feet each, since the sound propagates through the full layer depth. The effective depth of the 4th layer is only 94 feet, since the aircraft altitude at the time of PNLTM is 394 feet, which is 94 feet above the lower boundary of the 4th layer.

$$\begin{aligned}
 & (17.55 * 96 / 390) + 1^{\text{st}} \text{ layer minus microphone height} \\
 & (17.15 * 100 / 390) + \text{Entire } 2^{\text{nd}} \text{ layer depth} \\
 & (16.65 * 100 / 390) + \text{Entire } 3^{\text{rd}} \text{ layer depth} \\
 & (15.80 * 94 / 390) + \text{Portion of } 4^{\text{th}} \text{ layer affecting propagation} \\
 & = 16.795 \text{ dB / 1000 feet Average absorption coefficient, 3150 Hz}
 \end{aligned}$$

This calculation is repeated to obtain the average atmospheric absorption coefficient, $\alpha(i)$ for each one-third octave band. These $\alpha(i)$ values are then used in the calculation presented in Section A36.9.3.2.1.

247. Section A36.9.3.2.1.1 PNL T Correction.

PNLT Correction.

Convert the corrected values, $SPL(i)r$, to $PNLT_r$;

(b) Calculate the correction term Δ_1 using the following equation:

$$\Delta_1 = PNL T_r - PNL TM$$

c. Procedures

- (1) Application of Bandsharing Correction for “Simplified” Method: When the “Simplified” adjustment method is used, the Bandsharing Correction calculated for Test-Day data must be applied to PNLTr before calculation of $\Delta 1$. See the Supplemental Information and Procedures provided under Section A36.4.4.2 of this AC for details.
- (2) Application of High-Altitude Site Jet Noise Correction for “Simplified” Method: When the Equivalent Procedure for use of high-altitude test sites (Elevation > 1200 feet MSL) is employed, and when the resultant correction has not been applied to Test-Day data, the correction must be applied to the Reference-Day spectrum before calculation of PNLTr and $\Delta 1$. See Appendix 6 of the appended ICAO TM, for information on the equivalent procedure for testing at high-altitude sites.

248. Section A36.9.3.2.1.2

Add D_1 arithmetically to the EPNL calculated from the measured data.

249. Section A36.9.3.2.2

If, during a test flight, several peak values of PNLT that are within 2 dB of PNLT_M are observed, the procedure defined in section A36.9.3.2.1 must be applied at each peak, and the adjustment term, calculated according to section A36.9.3.2.1, must be added to each peak to give corresponding adjusted peak values of PNLT. If these peak values exceed the value at the moment of PNLT_M, the maximum value of such exceedance must be added as a further adjustment to the EPNL calculated from the measured data.

b. Supplemental Information

- (1) Identification of Multiple Peak PNLT Values: Peak PNLT values within 2 dB of PNLT_M must be identified for use in the adjustment of test to reference EPNL values. A “Delta Peak” adjustment is calculated and applied as follows:
 - For each secondary peak value of PNLT, adjust the associated test one-third-octave-band spectrum to reference conditions, per the procedure described in Section A36.9.3.2.1.
 - Subtract the reference PNLT_M value from each of the reference PNLT values (PNLT–PNLT_M) calculated for these secondary peaks. If any of these differences is positive set Delta Peak equal to the largest one.
 - Delta Peak must be added algebraically to the test EPNL values to obtain the reference EPNL values.

250. Section A36.9.3.3 Adjustments to Duration Correction.

251. Section A36.9.3.3.1

Whenever the measured flight paths and/or the ground velocities of the test conditions differ from the reference flight paths and/or the ground velocities of the reference conditions, duration adjustments must be applied to the EPNL values calculated from the measured data. The adjustments must be calculated as described below.

a. Supplemental Information

- (1) Duration Adjustments: A duration adjustment must be determined when the simplified data analysis method is used. This adjustment, identified as Delta 2 (Δ_2), accounts for the effect on duration due to (1) the altitude difference between a test airplane flight path, and a reference airplane flight path, (2) due to the difference between a test airplane airspeed and a reference airplane airspeed. Delta 2 can be positive or negative.

252. Section A36.9.3.3.2

For the flight path shown in Figure A36-6, the adjustment term is calculated as follows:

$$\Delta_2 = -7.5 \log(QK/Q_r K_r) + 10 \log(V/V_r)$$

(a) Add Δ_2 arithmetically to the EPNL calculated from the measured data.

253. Section A36.9.3.4 Source Noise Adjustments.

254. Section A36.9.3.4.1

To account for differences between the parameters affecting engine noise as measured in the certification flight tests, and those calculated or specified in the reference conditions, the source noise adjustment must be calculated and applied. The adjustment is determined from the manufacturer's data approved by the FAA. Typical data used for this adjustment are illustrated in Figure A36-8 that shows a curve of EPNL versus the engine control parameter μ with the EPNL data being corrected to all the other relevant reference conditions (airplane mass, speed and altitude, air temperature) and for the difference in noise between the test engine and the average engine (as defined in section B36.7(b)(7)). A sufficient number of data points over a range of values of μ are required to calculate the source noise adjustments for lateral, flyover and approach noise measurements.

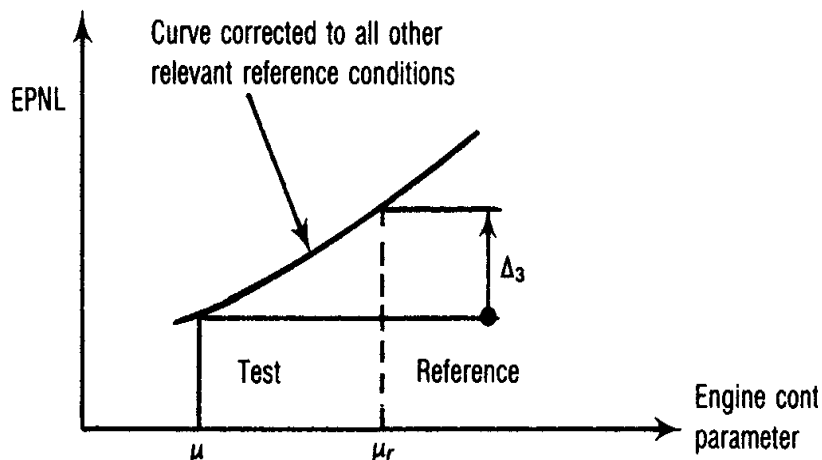


Figure B36-8: Noise Thrust Correction

255. Section A36.9.3.4.2

Calculate adjustment term D_3 by subtracting the EPNL value corresponding to the parameter m from the EPNL value corresponding to the parameter m_1 . Add D_3 arithmetically to the EPNL value calculated from the measured data.

256. Section A36.9.3.5 Symmetry Adjustments.

257. Section A36.9.3.5.1

A symmetry adjustment to each lateral noise value (determined at the section B36.4(b) measurement points), is to be made as follows:

- (a) **If the symmetrical measurement point is opposite the point where the highest noise level is obtained on the main lateral measurement line, the certification noise level is the arithmetic mean of the noise levels measured at these two points (see Figure A36-9(a));**
- (b) **If the condition described in paragraph (a) of this section is not met, then it is assumed that the variation of noise with the altitude of the airplane is the same on both sides; there is a constant difference between the lines of noise versus altitude on both sides (see Figure A36-9(b)). The certification noise level is the maximum value of the mean between these lines.**

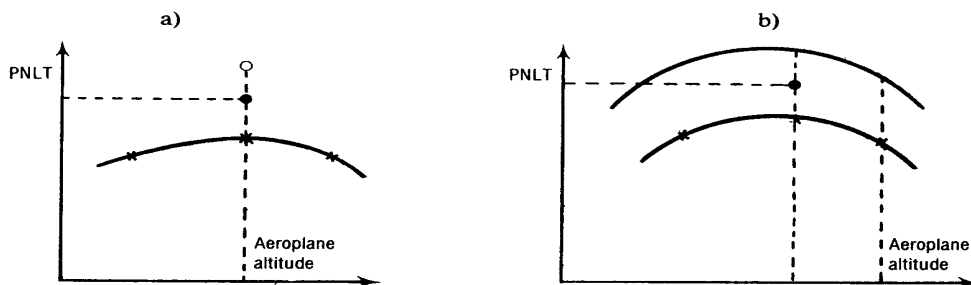


Figure A36-9: Symmetry Correction

a. Explanation

This section specifies the methodology for applying a symmetry adjustment to the lateral noise levels determined for each test run.

b. Supplemental Information

- (1) Guidance: Section 2.1.3 of the appended ICAO TM provides guidance on determination of lateral noise certification levels.
- (2) Measured Lateral Noise Levels: Measured lateral noise levels will not be the same at symmetrical noise measurement points even when the data is adjusted for airplane position (for flight directly over the extended runway centerline). This non-symmetrical nature of measured sideline noise is primarily attributed to the direction of engine or propeller rotation. Because of inlet shielding, turbojet powered airplanes may exhibit 1-2 dB differences in lateral noise levels. Turbo-propeller powered airplanes can exhibit differences in lateral noise levels in excess of 6dB. Due to their inherent lateral noise asymmetry, for propeller-driven airplanes, section B36.4 requires that simultaneous measurements be made at each and every test noise measurement point at its symmetrical position on the opposite side of the runway.

258. Section A36.9.4 Integrated method of adjustment.

259. Section A36.9.4.1 General.

As described in this section, the integrated adjustment method consists of recomputing under reference conditions points on the PNLT time history corresponding to measured points obtained during the tests, and computing EPNL directly for the new time history obtained in this way. The main principles are described in sections A36.9.4.2 through A36.9.4.4.1.

a. Explanation

This section specifies the methodology of the integrated method used for adjusting measured noise data to reference conditions

b. Supplemental Information

- (1) The integrated method is required when the adjustments to measured noise values are greater than 8 dB on take-off, greater than 4 dB on approach, or when the resulting final EPNL values on take-off or approach are within 1 dB of the limiting noise levels prescribed in Section B36.5 of this AC.
- (2) Section 6.6 of the Appended ICAO TM provides details of an approved integrated adjustment method when the airplane is operated at stabilized flight path and power conditions during the noise measurement period.

260. Section A36.9.4.2 PNLT computations.

(a) The portions of the test flight path and the reference flight path described below, and illustrated in Figure A36-10, include the noise time history that is relevant to the calculation of flyover and approach EPNL. In figure A36-10:

(1) XY represents the portion of the measured flight path that includes the noise time history relevant to the calculation of flyover and approach EPNL; X_rY_r represents the corresponding reference flight path.

(2) The points Q_0 , Q_1 , Q_n represent airplane positions on the measured flight path at time t_0 , t_1 and t_n respectively. Point Q_1 is the point at which the noise was emitted and observed as one-third octave values $SPL(i)_1$ at the noise measuring station K at time t_1 . Point Q_{r1} represents the corresponding position on the reference flight path for noise observed as $SPL(i)_{r1}$ at the reference measuring station K_r at time t_{r1} . Q_1K and $Q_{r1}K_r$ are respectively the measured and reference noise propagation paths, which in each case form the angle α_1 with their respective flight paths. Q_{r0} and Q_{rn} are similarly the points on the reference flight path corresponding to Q_0 and Q_n on the measured flight path. Q_0 and Q_n are chosen so that between Q_{r0} and Q_{rn} all values of $PNLT_r$ (computed as described in paragraphs A36.9.4.2.2 and A36.9.4.2.3) within 10 dB of the peak value are included.

(b) The portions of the test flight path and the reference flight path described below, and illustrated in Figure A36-11(a) and (b), include the noise time history that is relevant to the calculation of lateral EPNL.

(1) In figure A36-11(a) XY represents the portion of the measured flight path that includes the noise time history that is relevant to the calculation of Lateral EPNL; in figure A36-11(b), X_rY_r represents the corresponding portion of the reference flight path. For the Lateral noise measurement, sound propagation is affected not only by "inverse square" and atmospheric

attenuation, but also by ground absorption and reflection effects which depend mainly on the angle γ .

(2) The points Q_0 , Q_1 and Q_n represent airplane positions on the measured flight path at time t_0 , t_1 and t_n respectively. Point Q_1 is the point at which the noise was emitted and observed as one-third octave values $SPL(i)_1$ at the noise measuring station K at time t_1 . The point Q_{r1} represents the corresponding position on the reference flight path for noise observed as $SPL(i)_{r1}$ at the measuring station K_r at time t_{r1} . Q_1K and $Q_{r1}K_r$ are respectively the measured and reference noise propagation paths. Q_{r0} and Q_{rn} are similarly the points on the reference flight path corresponding to Q_0 and Q_n on the measured flight path. Q_0 and Q_n are chosen so that between Q_{r0} and Q_{rn} all values of $PNLT_r$ (computed as described in paragraphs A36.9.4.2.2 and A36.9.4.2.3) within 10 dB of the peak value are included. In this case K_r is only specified as being on a particular lateral line. The position of K_r and Q_{r1} are determined from the following requirements:

(A) Q_1K and $Q_{r1}K_r$ form the same angle α_1 with their respective flight paths; and

(B) The differences between the angles γ_1 and γ_{r1} must be minimized using a method, approved by the FAA. The differences between the angles are minimized since, for geometrical reasons, it is generally not possible to choose K_r so that the condition described in paragraph A36.9.4.2(b)(2)(A) is met while at the same time keeping γ_1 and γ_{r1} equal.

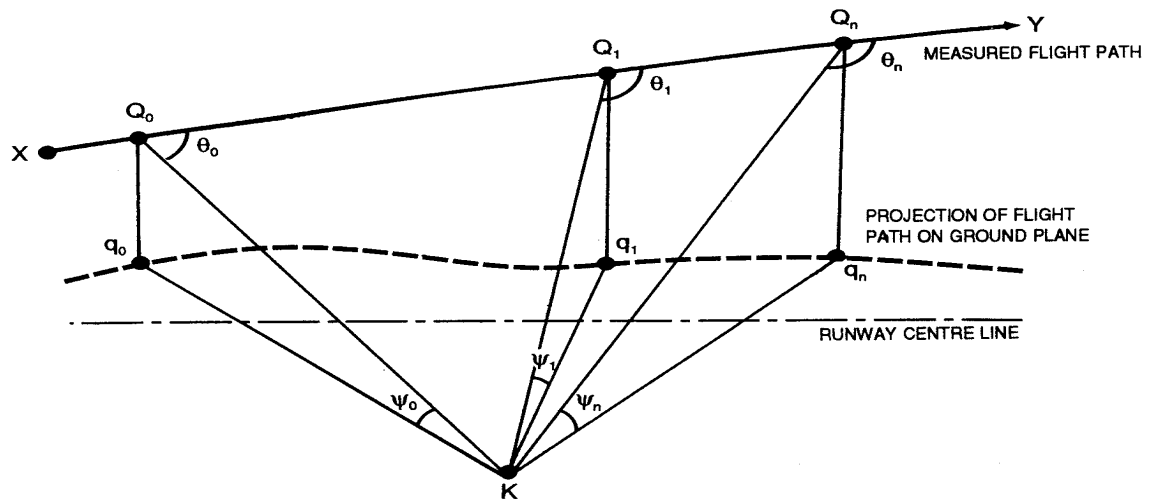


Figure B36-11 (a): Measured Flight Path

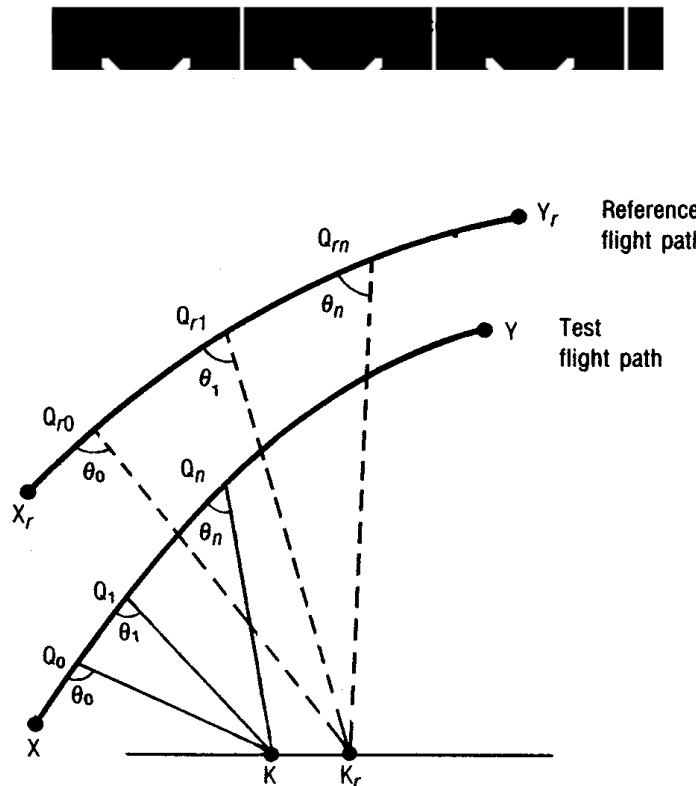
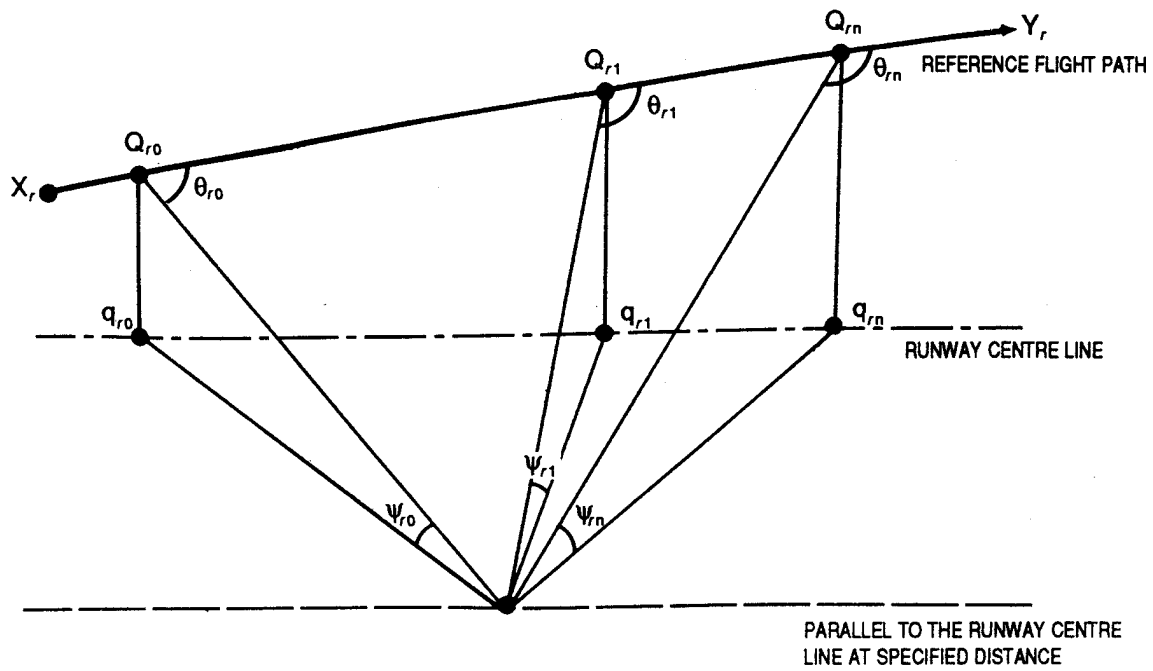


Figure A36-14: Corresponding between Measured and Reference Flight Paths for the application of the "Integrated" Correction Methods of Adjustments

a. Explanation

This section specifies the portions of the test and reference flight paths that are significant for computation of EPNL (i.e., encompassing the 10 dB-down points), the symbols for airplane positions at different time intervals, and noise angles (which are equated between respective test and reference flight paths).

b. Supplemental Information

- (1) Noise Emission Angles: For the integrated method, each 0.5-second noise data record will define a separate noise emission angle. This angle will then define the location of each time interval along the reference flight path (this may be different than 0.5 seconds). The different distances between the test and reference time intervals can determine the sound propagation path noise data adjustments required.

c. Procedure

- (1) Applicant's Responsibility: If the integrated method is used for lateral noise measurements and it is not possible to equate the elevation angle for the test flight path to that for the reference flight path after equating test and reference noise emission angles, then the elevation angle differences should be minimized and approved by the FAA.

261. Section A36.9.4.2.1

In paragraphs A36.9.4.2(a)(2) and (b)(2) the time t_{r1} is later (for $Q_{r1}K_r > Q_1K$) than t_1 by two separate amounts:

(1) The time taken for the airplane to travel the distance $Q_{r1}Q_{r0}$ at a speed V_r less the time taken for it to travel Q_1Q_0 at V ;

(2) The time taken for sound to travel the distance $Q_{r1}K_r - Q_1K$.

Note 1: For the flight paths described in paragraphs A36.9.4.2(a) and (b), if thrust or power cut-back is used there will be test and reference flight paths at full thrust or power and at cut-back thrust or power. Where the transient region between these affects the final result an interpolation must be made between them by an approved method such as that given in the current Advisory Circular for this part.

a. Explanation

This section specifies the factors that relate to the difference in the emission times between the reference flight path and the test flight path using the integrated method.

b. Supplementary Information

- (1) See Section 6.6 of the Appended ICAO TM for discussion of time interval computations using the integrated method.

262. Section A36.9.4.2.2

The measured values of $SPL(i)_1$ must be adjusted to the reference values $SPL(i)_{r1}$ to account for the differences between measured and reference noise path lengths and between measured and reference atmospheric conditions, using the methods of section A36.9.3.2.1 of this appendix. A

corresponding value of PNL_{r1} must be computed according to the method in section A36.4.2. Values of PNL_r must be computed for times t_0 through t_n .

263. Section A36.9.4.2.3

For each value of PNL_{r1} , a tone correction factor C_1 must be determined by analyzing the reference values $SPL(i)_r$ using the methods of section A36.4.3 of this appendix, and added to PNL_{r1} to yield $PNLT_{r1}$. Using the process described in this paragraph, values of $PNLT_r$ must be computed for times t_0 through t_n .

264. Section A36.9.4.3 Duration correction.

265. Section A36.9.4.3.1

The values of $PNLT_r$ corresponding to those of $PNLT$ at each one-half second interval must be plotted against time ($PNLT_{r1}$ at time t_{r1}). The duration correction must then be determined using the method of section A36.4.5.1 of this appendix, to yield $EPNL_r$.

a. Explanation

This section specifies the method of determining the duration correction needed to obtain $EPNL_r$ when using the “integrated” method.

b. Supplementary Information

- (1) See Section 6.6.7 of the appended ICAO TM for discussion of adjusted $EPNL$ computations when using the “integrated” method.

c. Procedures

- (1) Application of Bandsharing Correction for “Integrated” Method: When the “Integrated” adjustment method is used, a separate Bandsharing Correction must be calculated for the Reference-Day noise data, using the procedure described in A36.4.4.2. This adjustment must be applied to the maximum $PNLT_r$ before calculation of the Duration Correction and $EPNL_r$.
- (2) Application of High-Altitude Site Jet Noise Correction for “Integrated” Method: When the Equivalent Procedure for use of high-altitude test sites (Elevation > 1200 feet MSL) is employed, and the “Integrated” adjustment method is used to determine the Reference Day $EPNL$ ($EPNL_r$), the complete correction procedure must be applied to the entire 10 dB-down period of either: a) the Test-Day data set, or b) the Reference-Day data set. See Appendix 6 of the appended ICAO TM, for information on the equivalent procedure for testing at high-altitude sites.

266. Section A36.9.4.4 Source noise adjustment.

267. Section A36.9.4.4.1

A source noise adjustment, D_3 , must be determined using the methods of section A36.9.3.4 of this appendix.

268. Section A36.9.5 Flight path identification positions.

Position	Description
A	Start of Takeoff roll
B	Lift-off
C	Start of first constant climb
D	Start of thrust reduction
E	Start of second constant climb
F	End of noise certification Takeoff flight path
G	Start of noise certification Approach flight path
H	Position on Approach path directly above noise measuring station
I	Start of level-off
J	Touchdown
K	Noise measurement point
K_r	Reference measurement point
K₁	Flyover noise measurement point
K₂	Lateral noise measurement point
K₃	Approach noise measurement point
M	End of noise certification Takeoff flight track
O	Threshold of Approach end of runway
P	Start of noise certification Approach flight track
Q	Position on measured Takeoff flight path corresponding to apparent PNLTM at station K. See section B36.9.3.2
Q_r	Position on corrected Takeoff flight path corresponding to PNLTM at station K. See section B36.9.3.2
V	airplane test speed
V_r	airplane reference speed

269. Section A36.9.6 Flight path distances.

Distance	Unit	Meaning
AB	feet (meters)	Length of takeoff roll. The distance along the runway between the start of takeoff roll and lift off.
AK	feet (meters)	Takeoff measurement distance. The distance from the start of roll to the takeoff noise measurement station along the extended center line of the runway.
AM	feet (meters)	Takeoff flight track distance. The distance from the start of roll to the takeoff flight track position along the extended center line of the runway after which the position of the airplane need no longer be recorded.
QK	feet (meters)	Measured noise path. The distance from the measured airplane position Q to station K.
Q_rK_r	feet (meters)	Reference noise path. The distance from the reference airplane position Q_r to station K_r.
K₃H	feet (meters)	Airplane approach height. The height of the airplane above the approach measuring station.
OK₃	feet (meters)	Approach measurement distance. The distance from the runway threshold to the approach measurement station along the extended center line of the runway.

<i>OP</i>	<i>feet (meters)</i>	<i>Approach flight track distance. The distance from the runway threshold to the approach flight track position along the extended center line of the runway after which the position of the airplane need no longer be recorded.</i>
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a. Explanation

This section specifies the flight path identification positions, their symbols, and associated units.

270. -289 [RESERVED]

**XIII. APPENDIX B TO PART 36--NOISE LEVELS FOR TRANSPORT CATEGORY AND JET AIRPLANES
UNDER Section 36.103**

- 290. Section Noise Levels for Transport Category and Jet Airplanes
- 291. B36.1 Noise measurement and evaluation.
- 292. B36.2 Noise evaluation metric.
- 293. B36.3 Reference noise measurement points.
- 294. B36.4 Test noise measurement.
- 295. B36.5 Maximum noise levels.
- 296. B36.6 Trade-offs.
- 297. B36.7 Noise certification reference procedures.
- 298. B36.8 Test procedures.

a. Explanation

Appendix B addresses the noise measurement and evaluation requirements, test and reference procedures, and maximum noise levels that FAA uses as the basis for assessment of compliance of subsonic transport category and turbojet powered large airplanes and turbojet powered airplanes with Part 36.

299. Section B36.1 Noise measurement and evaluation.

Compliance with this appendix must be shown with noise levels measured and evaluated using the procedures of appendix A of this part, or under approved equivalent procedures..

a. Explanation

This Section specifies that an applicant's noise measurement and evaluation methods must conform to those of Appendix A or to FAA approved equivalent procedures for compliance with the maximum noise level requirements of Part 36 (See Section B36.5).

b. Procedure

- (1) FAA Responsibility: FAA must determine that compliance with the requirements of this Appendix have been satisfactorily demonstrated by the applicant prior to certification of an airplane.

300. Section B36.2 Noise evaluation metric.

The noise evaluation metric is the effective perceived noise level expressed in EPNdB, as calculated using the procedures of appendix A of this part.

a. Explanation

This Section specifies that the noise evaluation metric to be used in showing compliance with the noise limits is the Effective Perceived Noise Level (in units of EPNDB). See Section A36.4 for a description of EPNL and the methodology for its calculation.

c. Supplemental Information

- (1) EPNL Noise Rating: Part 36 was designed so that applicants would generate repeatable and reliable airplane noise levels at flyover, lateral and approach noise measurement points for comparison to noise limits at those points. EPNL was selected as the metric best suited for the Part 36 design objectives. It was developed to account for the effects of tones, and other aspects of aircraft noise that are annoying to persons on the ground."

301. Section B36.3 Reference noise measurement points.

When tested using the procedures of this part, except as provided in section B36.6, an airplane may not exceed the noise levels specified in section B36.5 at the following points on level terrain:

(a) Lateral full-power reference noise measurement point:

(1) For jet airplanes: the point on a line parallel to and 1,476 feet (450 m) from the runway centerline, or extended centerline, where the noise level after lift-off is at a maximum during takeoff. For the purpose of showing compliance with Stage 1 or Stage 2 noise limits for an airplane powered by more than three jet engines, the distance from the runway centerline must be 0.35 nautical miles (648 m).

(2) For propeller-driven airplanes: the point on the extended centerline of the runway above which the airplane, at full takeoff power, reaches a height of 2,133 feet (650 meters). For tests conducted before March 20, 2002, an applicant may use the measurement point specified in section B36.3(a)(1) as an alternative.

(b) Flyover reference noise measurement point: the point on the extended centerline of the runway that is 21,325 feet (6,500m) from the start of the takeoff roll;

(c) Approach reference noise measurement point: the point on the extended centerline of the runway that is 6,562 feet (2,000 m) from the runway threshold. On level ground, this corresponds to a position that is 394 feet (120 m) vertically below the 3° descent path, which originates at a point on the runway 984 feet (300 m) beyond the threshold.

a. Explanation

This Section specifies the locations of reference noise measurement points for flyover, lateral and approach noise measurements.

302. Section B36.4 Test noise measurement points.

(a) If the test noise measurement points are not located at the reference noise measurement points, any corrections for the difference in position are to be made using the same adjustment procedures as for the differences between test and reference flight paths.

(b) The applicant must obtain a sufficient number of lateral test noise measurement points to demonstrate to the FAA that the maximum noise level on the appropriate lateral line has been determined. For jet airplanes, simultaneous measurements must be made at one test noise measurement point at its symmetrical point on the other side of the runway. Propeller-driven airplanes have an inherent asymmetry in lateral noise. Therefore, simultaneous measurements must be made at each and every test noise measurement point at its symmetrical position on the opposite side of the runway. The measurement points are considered to be symmetrical if they are longitudinally within 33 feet (±10 meters) of each other.

a. Explanation

This Section specifies FAA requirements when test noise measurement points are not located at reference noise measurement positions and the criteria for selection of lateral noise measurement points for jet airplanes and propeller-driven airplanes.

b. Supplemental Information

- (1) Measured Lateral Noise Levels: Measured lateral noise levels may not be the same at symmetrical noise measurement points even when the data is adjusted for airplane position (for flight directly over the extended runway centerline). The direction of engine or propeller rotation may be an important factor in the non-symmetrical nature of measured lateral noise. Inlet shielding may cause turbojet-powered airplanes to exhibit 1-2 dB differences in lateral noise levels. Propeller-driven airplanes may exhibit

differences in lateral noise levels in excess of 6 dB. Due to their inherent lateral noise asymmetry, for propeller-driven airplanes, section B36.4 requires that simultaneous measurements be made at each and every test noise measurement point at its symmetrical position on the opposite side of the runway.

- (2) Maximum Lateral Noise Levels: When an applicant conducts noise measurements at several altitudes as proposed in an FAA approved noise compliance demonstration plan, the resulting data are used to determine the maximum lateral noise level (valid certification noise test data cannot be discarded). Typically, a 2nd order curve fit through the adjusted noise levels as a function of airplane altitude is sufficient to determine the maximum average lateral noise level and the altitude at which it occurred.
- (3) Equivalent Procedures: Section 2.1.3.2 of the appended ICAO Environmental Technical Manual describes an equivalent procedure to the requirements of Section B36.4 for determination of maximum lateral noise levels for turbojet powered airplanes. Unlike the ICAO TM Section 2.1.3.2 (b), the FAA does not restrict consideration of this equivalency to engines with bypass ratios of more than 2. Prior approval from the FAA is required to use this equivalent procedure.

c. Procedure

- (1) Applicant's Responsibility: An applicant must include proposed equivalent procedures for lateral noise measurements in a noise compliance demonstration plan for FAA review and approval.

303. Section B36.5 Maximum noise levels.

Except as provided in section B36.6 of this appendix, maximum noise levels, when determined in accordance with the noise evaluation methods of appendix A of this part, may not exceed the following:

(a) For acoustical changes to Stage 1 airplanes, regardless of the number of engines, the noise levels prescribed under § 36.7(c) of this part.

(b) For any Stage 2 airplane regardless of the number of engines:

(1) Flyover: 108 EPNdB for maximum weight of 600,000 pounds or more; for each halving of maximum weight (from 600,000 pounds), reduce the limit by 5 EPNdB; the limit is 93 EPNdB for a maximum weight of 75,000 pounds or less.

(2) Lateral and approach: 108 EPNdB for maximum weight of 600,000 pounds or more; for each halving of maximum weight (from 600,000 pounds), reduce the limit by 2 EPNdB; the limit is 102 EPNdB for a maximum weight of 75,000 pounds or less.

(c) For any Stage 3 airplane:

(1) Flyover.

(i) For airplanes with more than 3 engines: 106 EPNdB for maximum weight of 850,000 pounds or more; for each halving of maximum weight (from 850,000 pounds), reduce the limit by 4 EPNdB; the limit is 89 EPNdB for a maximum weight of 44,673 pounds or less;

(ii) For airplanes with 3 engines: 104 EPNdB for maximum weight of 850,000 pounds or more; for each halving of maximum weight (from 850,000 pounds), reduce the limit by 4 EPNdB; the limit is 89 EPNdB for a maximum weight of 63,177 pounds or less; and

(iii) For airplanes with fewer than 3 engines: 101 EPNdB for maximum weight of 850,000 pounds or more; for each halving of maximum weight (from 850,000 pounds), reduce the limit by 4 EPNdB; the limit is 89 EPNdB for a maximum weight of 106,250 pounds or less.

(2) Lateral, regardless of the number of engines: 103 EPNdB for maximum weight of 882,000 pounds or more; for each halving of maximum weight (from 882,000 pounds), reduce the limit by 2.56 EPNdB; the limit is 94 EPNdB for a maximum weight of 77,200 pounds or less.

(3) Approach, regardless of the number of engines: 105 EPNdB for maximum weight of 617,300 pounds or more; for each halving of maximum weight (from 617,300 pounds), reduce the limit by 2.33 EPNdB; the limit is 98 EPNdB for a maximum weight of 77,200 pounds or less.

a. Explanation

This section specifies noise level limits at flyover, lateral and approach reference noise measurement points as a function of airplane maximum takeoff gross weight. For the flyover noise measurement point, the maximum noise levels are specified for the number of airplane engines as well as maximum weight.

b. Supplemental Information

- (1) Stage Definitions: Definitions of Stage 1, Stage 2, and Stage 3 airplanes are given in Section 36.1 of Subpart A.
- (2) Acoustical Change: Requirements for FAA approval of Stage 1, Stage 2 and Stage 3 airplane Acoustical Changes, applied for under, Part 21.93 (b) are specified in Section 36.7 of Subpart A.

c. Procedures

- (1) Noise Limits: Flyover, lateral and approach noise limits for Stage 2 and Stage 3 Airplanes are given below. FAA uses Equations A through E to determine these limits.

Stage	No. of Engines	Maximum Weight (MTOGW), pounds	Flyover Limit, dB	Lateral Limit, dB	Approach Limit, dB
2	Any number	75,000 and less	93.0	102.0	102.0
2	Any number	between 75,000 and 600,000	See Eqn. A	See Eqn. B	See Eqn. B
2	Any number	600,000 and more	108.0	108.0	108.0
3	Fewer than 3	106,250 and less	89.0		
3	Fewer than 3	between 106,250 and 850,000	See Eqn. C		
3	Fewer than 3	850,000 and more	101		
3	Three	63,177 and less	89.0		
3	Three	between 63,177 and 850,000	See Eqn. C		
3	Three	850,000 and more	104.0		
3	More than 3	44,673 and less	89.0		
3	More than 3	between 44,673 and 850,000	See Eqn. C		
3	More than 3	850,000 and more	106.0		
3	Any number	77,200 and less		94.0	
3	Any number	between 77,200 and 882,000		See Eqn. D	
3	Any number	882,000 and more		103.0	
3	Any number	77,200 and less			98.0
3	Any number	between 77,200 and 617,300			See Eqn. E
3	Any number	617,300 and more			105.0

Eqn. A: Limit Flyover EPNL = $93.0 + 5.0 [(\log (\text{Maximum weight} / 75,000)) \div (\log 2.0)]$

Eqn. B: Limit Approach EPNL = $102.0 + 2.0 [(\log (\text{Maximum weight} / 75,000)) \div (\log 2.0)]$

Eqn. C: Limit Flyover EPNL = $89.0 + 4.0 [(\log (\text{Maximum weight} / 'K')) \div (\log 2.0)]$, where:

Number of Engines	Eqn. C 'K' value
Fewer than 3	106,250

Three	63,177
More than 3	44,673

Eqn. D: Limit Lateral EPNL = $94.0 + 2.56 [(\log (\text{Maximum weight } / 77,200)) \div (\log 2.0)]$

Eqn. E: Limit Approach EPNL = $98.0 + 2.33 [(\log (\text{Maximum weight } / 77,200)) \div (\log 2.0)]$

Note: Maximum weights are considered to be the certificated maximum takeoff gross weight (MTOGW) at brake release for all certification noise level limits (Flyover, Lateral and Approach).

Graphs of Noise Limits: Figures 9 through 13 (summarized below) provide graphs of flyover, lateral and approach noise limits for Stage 2 and Stage 3 airplanes as a function of maximum weight.

Figure Number	Conditions	Number of Engines	Stage of Compliance
9	Flyover	Less than 3	2 and 3
10	Flyover	3	2 and 3
11	Flyover	More than 3	2 and 3
12	Lateral	Any number	2 and 3
13	Approach	Any number	2 and 3

Note: These graphical representations must not be used in place of Equations A through E (given above) to determine noise limits for an airplane's compliance with Part 36.

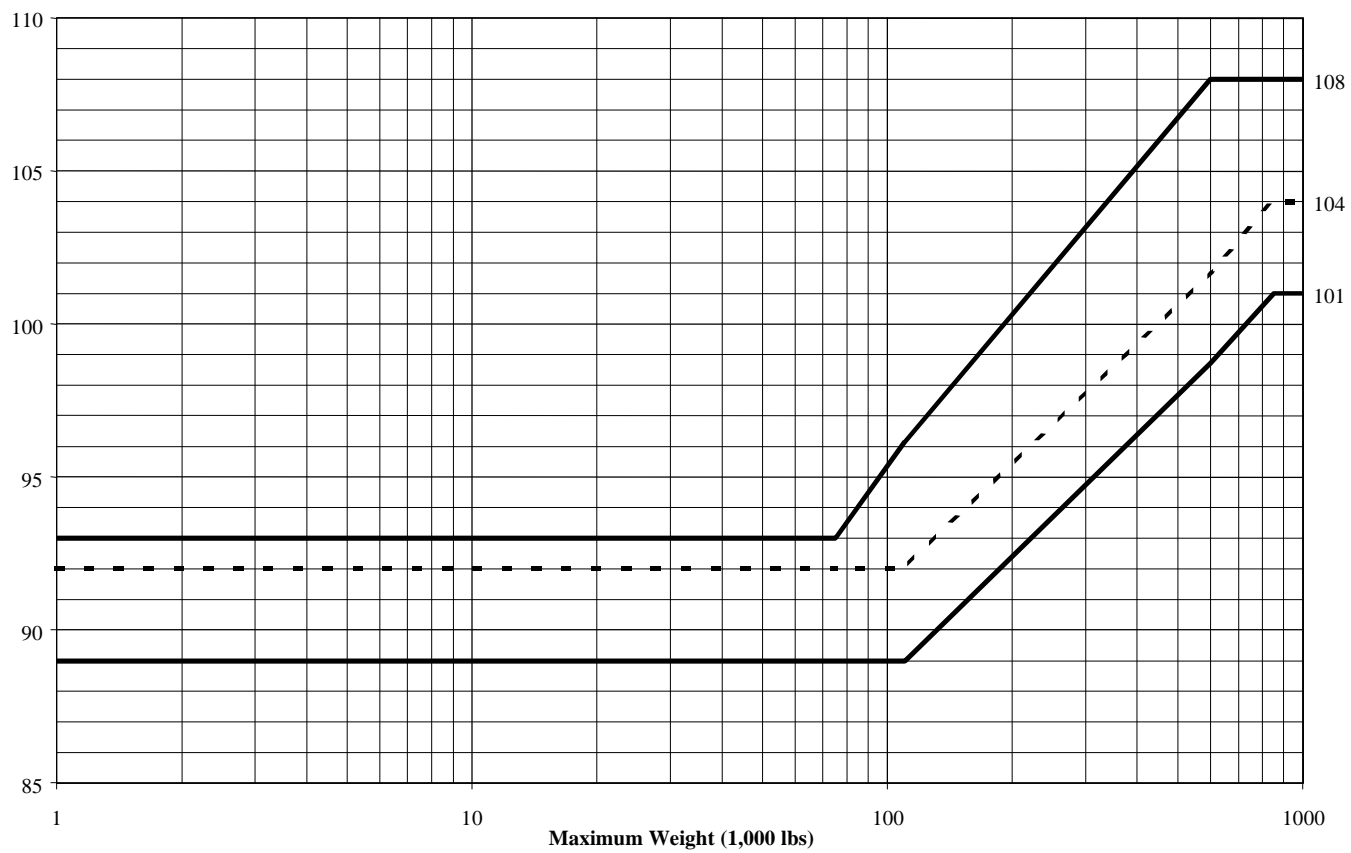


Figure 9: Flyover Noise Limits – Less than 3 engines

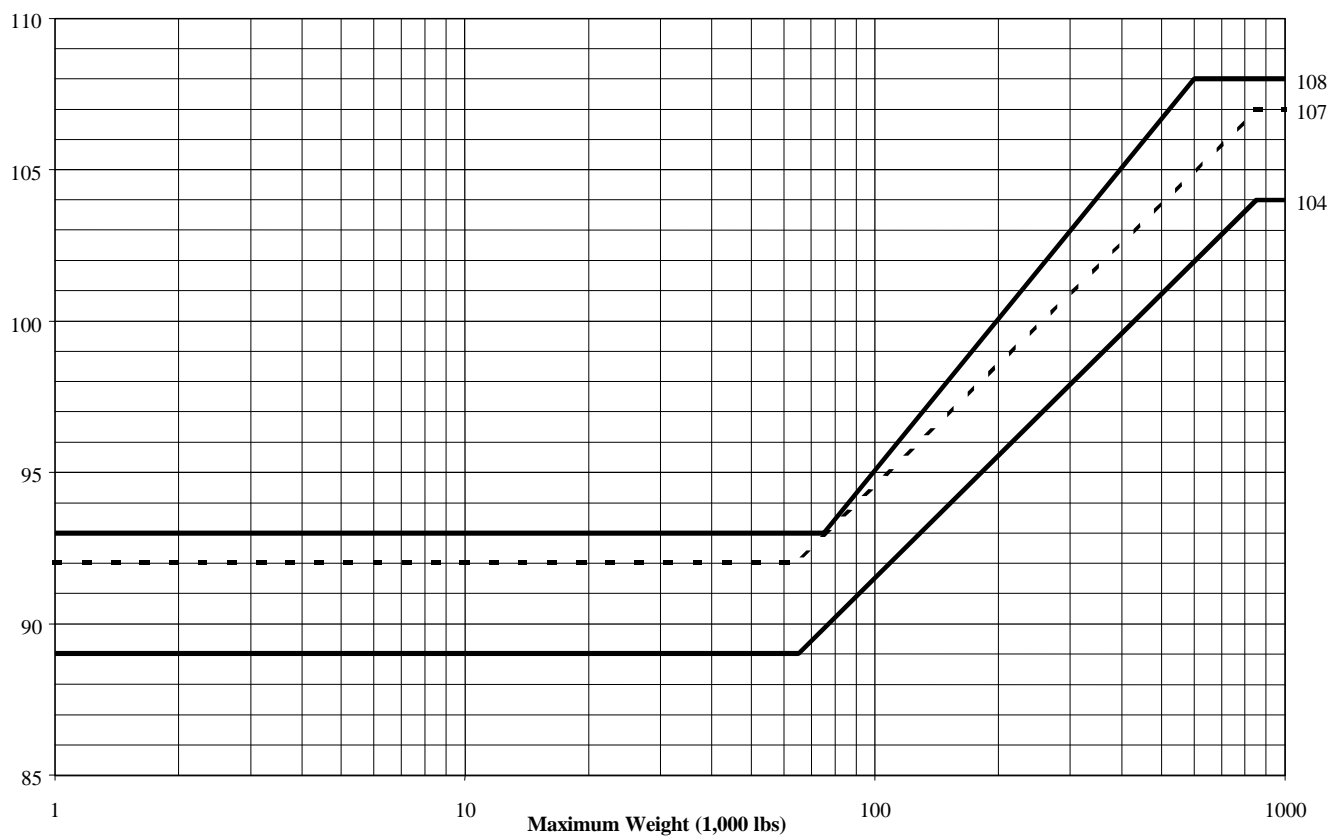


Figure 10: Flyover Noise Limits - 3 Engines

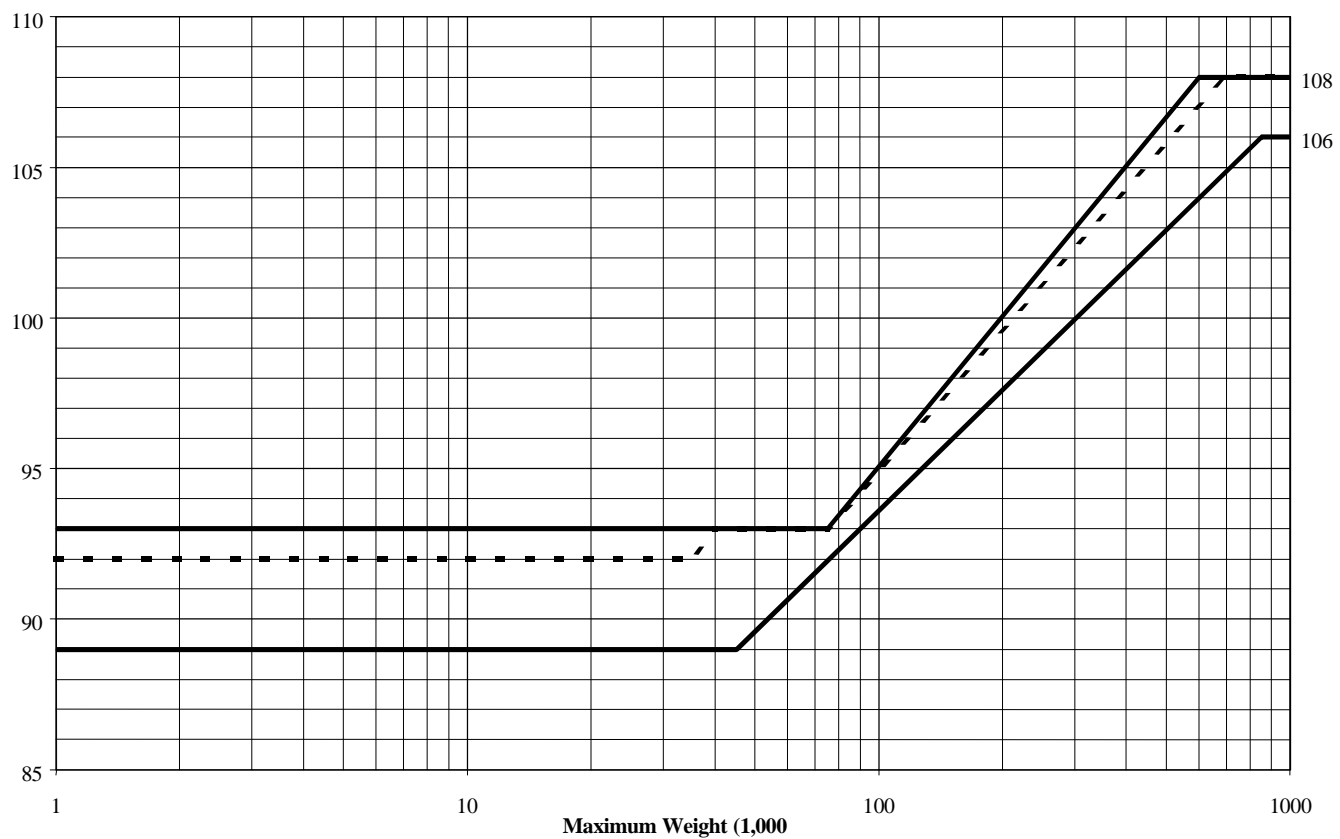


Figure 11: Flyover Noise Limits - More than 3 engines

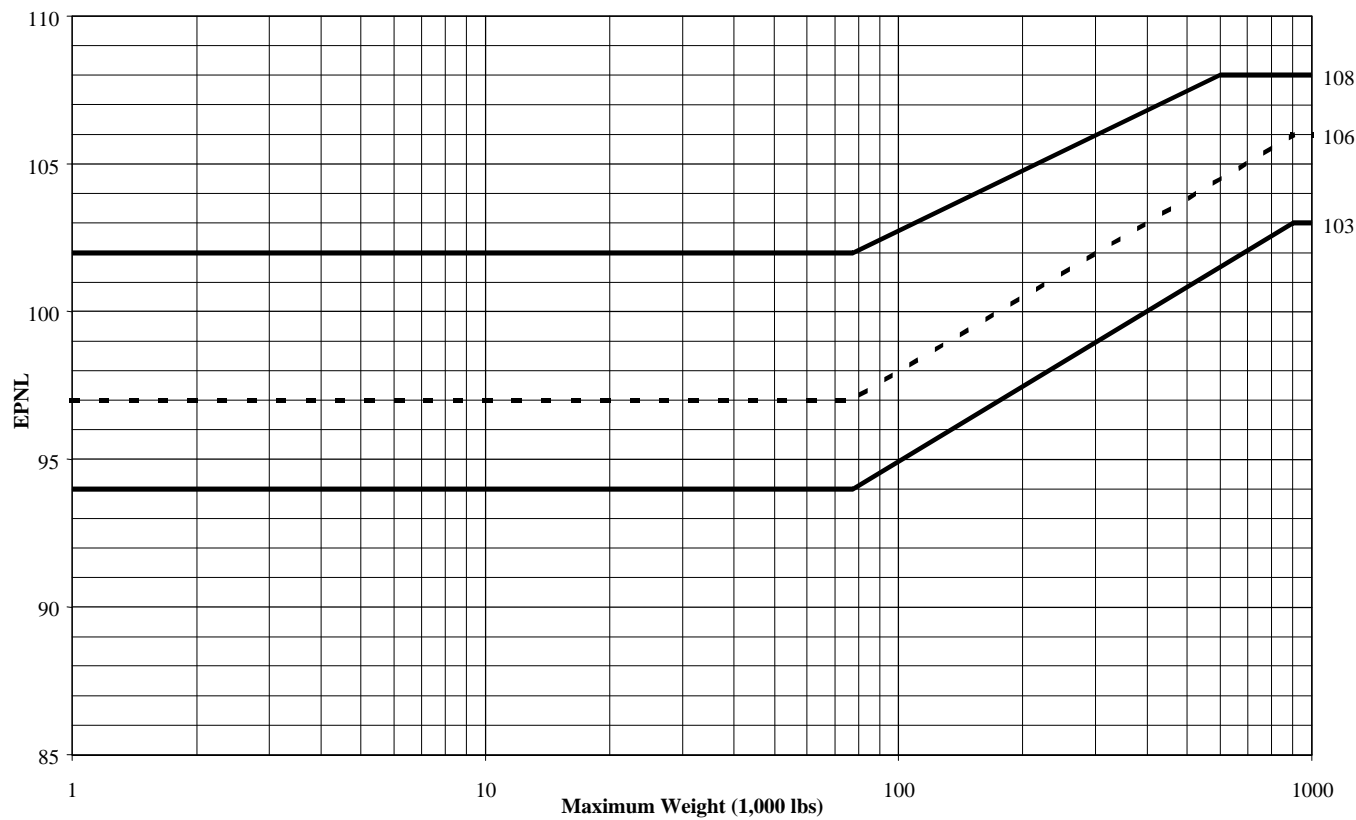


Figure 12: Lateral Noise Limits

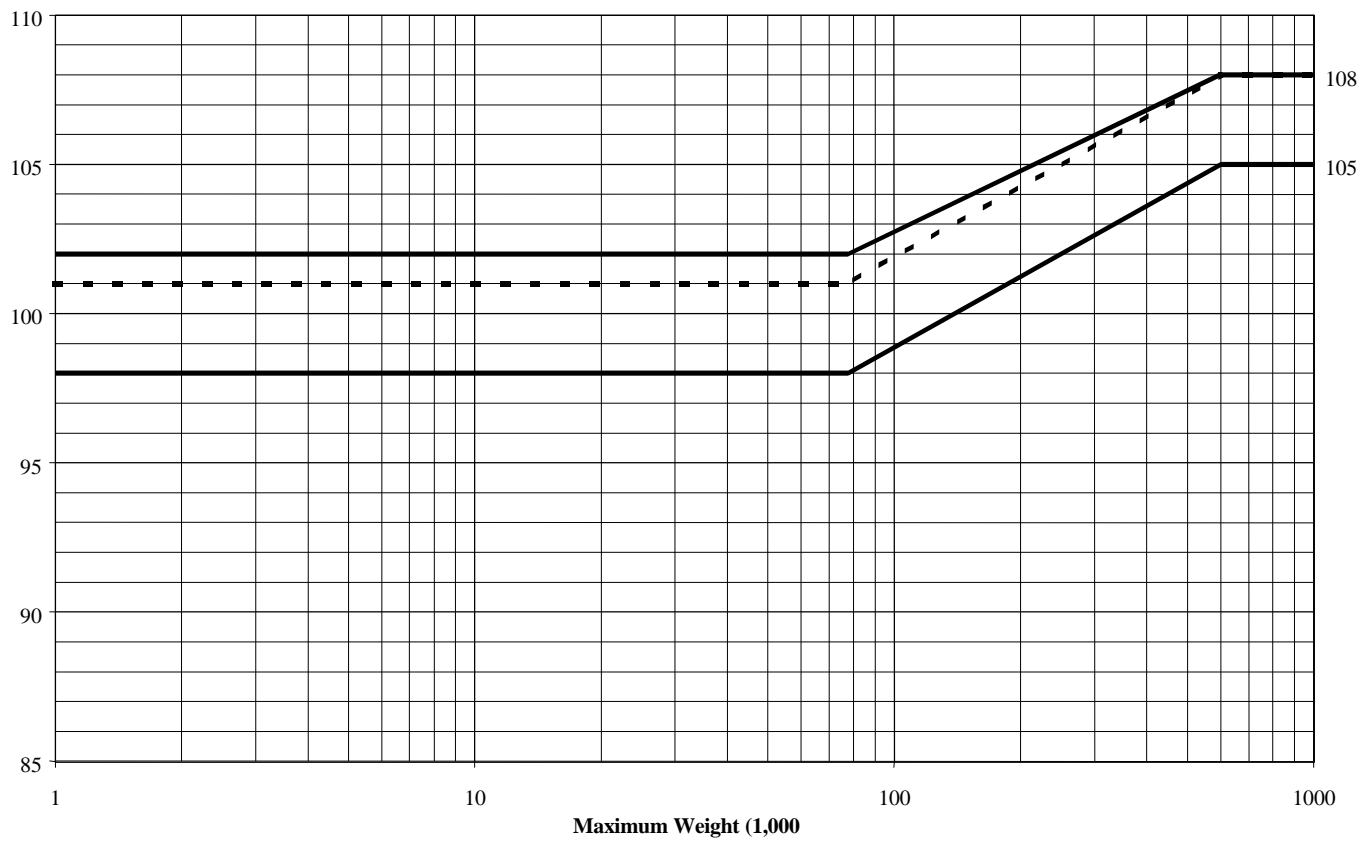


Figure 13: Approach Noise Limits

304. Section B36.6 Trade-offs.

Except when prohibited by sections 36.7(c)(1) and 36.7(d)(1)(ii), if the maximum noise levels are exceeded at any one or two measurement points, the following conditions must be met:

(a) The sum of the exceedance(s) may not be greater than 3 EPNdB;

(b) Any exceedance at any single point may not be greater than 2 EPNdB, and

(c) Any exceedance(s) must be offset by a corresponding amount at another point or points.

a. Explanation

This Section specifies the noise level tradeoffs an applicant may use in demonstrating Stage 2 and Stage 3 compliance with Part 36.

b. Supplemental Information

- (1) Tradeoff Provisions: Tradeoffs are permitted in determining compliance with the noise limits requirements of Part 36 because of the cumulative aspects of noise exposure. Limited "exceedances" to the flyover, lateral and approach noise limits are acceptable when compensated by noise reductions at the other noise measurement points,
- (2) Stage 1 Airplanes: FAA does not permit an applicant to use tradeoffs to increase Stage 1 airplane flyover, lateral or approach noise levels.

c. Procedure

- (1) Use of Tradeoffs: The following example demonstrates how tradeoffs are used:

Airplane Classification = Stage 3

Number of Engines = 3

Airplane MTOGW = 300,000 pounds

Stage 3 Noise Limits:

Flyover = 98.0 EPNdB

Lateral = 99.0 EPNdB

Approach = 102.6 EPNdB

Demonstrated Noise Levels:

Flyover = 99.8 EPNdB

Lateral = 98.2 EPNdB

Approach = 101.5 EPNdB

Total Exceedance:

Flyover = +1.8 EPNdB

Total Reduction:

Lateral + Approach = (-0.8) + (-1.1) = -1.9 EPNdB

This airplane complies with Part 36 noise limits requirements for a Stage 3 airplane through the use of tradeoffs.

305. Section B36.7 Noise certification reference procedures.

306. Section B36.7(a) General conditions:

(1) All reference procedures must meet the requirements of section 36.3 of this part.

(2) Calculations of airplane performance and flight path must be made using the reference procedures and must be approved by the FAA.

(3) Applicants must use the takeoff and approach reference procedures prescribed in paragraphs (b) and (c) of this section.

(4) [Reserved]

(5) The reference procedures must be determined for the following reference conditions. The reference atmosphere is homogeneous in terms of temperature and relative humidity when used for the calculation of atmospheric absorption coefficients.

(i) Sea level atmospheric pressure of 2116 pounds per square foot (psf) (1013.25 hPa);

(ii) Ambient sea-level air temperature of 77°F (25°C, i.e. ISA+10°C);

(iii) Relative humidity of 70 per cent; and

(iv) Zero wind.

(v) In defining the reference takeoff flight path(s) for the takeoff and lateral noise measurements, the runway gradient is zero.

a. Explanation

This Section specifies the airworthiness criteria, reference atmospheric conditions and runway gradients necessary for calculation of takeoff and approach reference procedures

b. Supplemental Information

(1) Reference Conditions and Procedures: In order to have a common basis of comparison of the reference EPNL values, which are obtained for airplanes tested under a range of conditions, with the Part 36 noise limits, uniform reference conditions and procedures are required.

(2) Equivalent Procedures: The FAA does not permit equivalent procedures for certification reference procedures (e.g., 3° glide path).

307. Section B36.7(b) Takeoff reference procedure:

The takeoff reference flight path is to be calculated using the following:

308. Section B36.7 (b)(1)

(1) Average engine takeoff thrust or power must be used from the start of takeoff to the point where at least the following height above runway level is reached. The takeoff thrust/power used must be the maximum available for normal operations given in the performance section of the airplane flight manual under the reference atmospheric conditions given in section B36.7(a)(5).

(i) For Stage 1 airplanes and for Stage 2 airplanes that do not have jet engines with a bypass ratio of 2 or more, the following apply:

(A): For airplanes with more than three jet engines--700 feet (214 meters).

(B): For all other airplanes--1,000 feet (305 meters).

(ii) For Stage 2 airplanes that have jet engines with a bypass ratio of 2 or more and for Stage 3 airplanes, the following apply:

(A): For airplanes with more than three engines--689 feet (210 meters).

(B): For airplanes with three engines--853 feet (260 meters).

(C) For airplanes with fewer than three engines--984 feet (300 meters).

a. Explanation

This Section specifies the reference engine thrust (power) and minimum altitude for thrust (power) reduction that an applicant must use to calculate reference flight paths for Stage 1, Stage 2, and Stage 3 airplanes.

b. Supplemental Information

- (1) Takeoff Without Thrust Reduction: Average engine takeoff thrust (power) may be used throughout the takeoff flight path without reducing thrust (power). Some applicants find that it is simpler to only test with takeoff thrust (power) - when reference EPNL values do not exceed Part 36 noise limits. This is especially true for turboprop powered transport category airplanes. After March 19, 2002, lateral noise levels must be determined using takeoff thrust (power) based on a flight path which takeoff thrust (power) is used throughout, i.e., thrust (power) reduction will not be permitted.

c. Procedures

- (1) Reference Takeoff Procedure With Thrust (Power) Reduction: For calculation of a takeoff reference procedure that includes a thrust (power) reduction, average engine takeoff thrust (power) is used at the point of brake release and maintained as the airplane proceeds along the runway, rotates and lifts off according to normal airworthiness requirements. The airplane then retracts the landing gear, and establishes a first segment climb gradient prior to reaching an appropriate altitude for thrust (power) reduction. Beyond this altitude the second segment climb gradient is established at reduced thrust (power) and maintained throughout the 10 dB-down period. Aerodynamic control surfaces (including flap position) are maintained constant throughout this procedure. See Section 2.2.1 of the appended ICAO TM.

- (2) Thrust (Power) Reduction Altitude: The thrust (power) reduction altitude proposed by the applicant must be equal to or greater than the minimum cutback heights specified in section B36.7(b)(1).

Note: FAA policy requires an applicant to take into accounts the following two airplane operational factors in determining an altitude for thrust (power) reduction within a reference flight path:

- (a) A one-second delay to account for pilot recognition and response prior to movement of the throttles to the reduced thrust (power) position. This policy is also included in section 2.2.1 of the appended ICAO TM.
 - (b) An average period of time for an airplanes engines to spool-down from takeoff thrust (power) to reduced thrust (power).
- (3) Spool-Down Tests: FAA witnessed flight tests of an airplane to be used for noise certification measurements are required to obtain at least six acceptable spool-down times of all engines from average engine takeoff thrust (power) to reduced thrust (power) at the lowest maximum weight to be certified. These tests should be conducted at altitudes approximately 3000 feet AGL and at airspeeds comparable to reference airspeeds as defined in Section B36.7 (b) (1) (iv). An applicant's proposal for these tests must be included in a noise compliance demonstration plan.

309. Section B36.7 (b)(2)

Upon reaching the height specified in paragraph (b)(1) of this section, airplane thrust or power must not be reduced below that required to maintain either of the following, whichever is greater:

- (i) A climb gradient of 4 per cent; or***
- (ii) In the case of multi-engine airplanes, level flight with one engine inoperative.***

a. Explanation

This Section specifies the minimum thrust (power) that must be maintained after an airplane has reached a minimum altitude for thrust reduction as required by Section B36.7 (b) (1):

b. Supplemental Information

- (1) Lapse Rate Effect on Engine Thrust (Power): The climb gradient after reducing thrust may decrease because, for a constant power setting, as the airplane altitude increases there is a decrease in engine thrust (power) due to lapse rate
- (2) Single Engine Airplane Reduced Thrust (Power) Requirements: For single engine airplanes, the minimum reduced thrust (power) required is that which is necessary to maintain a 4% climb gradient.

310. Section B36.7 (b)(3)

For the purpose of determining the lateral noise level, the reference flight path must be calculated using full takeoff power throughout the test run without a reduction in thrust or power. For tests conducted before March 20, 2002, a single reference flight path that includes thrust cutback in accordance with paragraph (b)(1) of this section, is an acceptable alternative in determining the lateral noise level.

a. Explanation

This section specifies criteria for an applicant to calculate lateral reference flight paths before and after March 20, 2002.

311. Section B36.7 (b)(4)

The takeoff reference speed is the all-engine operating takeoff climb speed selected by the applicant for use in normal operation; this speed must be at least V_2+10kt (V_2+19km/h) but may not be greater than V_2+20kt (V_2+37km/h). This speed must be attained as soon as practicable after lift-off and be maintained throughout the takeoff noise certification test. For Concorde airplanes, the test day speeds and the acoustic day reference speed are the minimum approved value of $V_2 +35$ knots, or the all-engines-operating speed at 35 feet, whichever speed is greater as determined under the regulations constituting the type certification basis of the airplane; this reference speed may not exceed 250 knots. For all airplanes, noise values measured at the test day speeds must be corrected to the acoustic day reference speed.

a. Explanation

This Section specifies airspeed criteria that an applicant must use to calculate the takeoff reference flight path of subsonic airplanes and Concorde airplanes.

b. Supplemental Information

- (1) Supersonic Airplanes: This AC does not address the noise certification requirements for supersonic transport category airplanes, other than Concorde (See Section 1g).

c. Procedures

- (1) V_2 Takeoff Airspeed: Criteria for determining V_2 takeoff airspeeds are specified in 14 CFR Part 25.107 "Takeoff Speeds".
- (2) Applicant's Responsibility: The applicant is responsible for determination of appropriate takeoff reference airspeeds for airplane maximum weights

312. Section B36.7 (b)(5)

The takeoff configuration selected by the applicant must be maintained constantly throughout the takeoff reference procedure, except that the landing gear may be retracted. Configuration means the center of gravity position, and the status of the airplane systems that can affect airplane

performance or noise. Examples include, the position of lift augmentation devices, whether the APU is operating, and whether air bleeds and engine power take-offs are operating;

b. Supplemental Information

- (1) Applicant's Options for Selection of Takeoff Configuration: The noise certification takeoff configuration that is selected by the applicant must be within the airworthiness approved configurations, as recorded in the AFM. Example: If the applicant has certificated flap settings 2, 5 and 10 and those settings are identified in the AFM, then they are valid options for noise measurements during takeoff. Flap setting 0 is not a valid option in this example. Noise certification compliance for a configuration that is different from the tested configuration may require re-testing or an equivalency finding by the FAA.

c. Procedure

- (1) Applicant's Responsibility: An applicant is responsible for demonstrating that an appropriate airplane takeoff configuration is selected and maintained constant in calculating a reference takeoff procedure.

313. Section B36.7 (b)(6)

The weight of the airplane at the brake release must be the maximum takeoff weight at which the noise certification is requested, which may result in an operating limitation as specified in § 36.1581(d); and

a. Explanation

This Section specifies criteria for defining a reference maximum takeoff weight of an airplane.

b. Supplemental Information

- (1) Part 36 Section 36.1581 Requirements: An airplane reference maximum takeoff weight for noise certification which is less than the maximum weight established under applicable airworthiness requirements must be furnished as operating limitations in the limitations section of the airplane flight manual.

c. Procedure

- (1) Applicant's Responsibility: An applicant must define and obtain FAA approval of an airplane maximum takeoff weight to calculate reference EPNL values.

314. Section B36.7 (b)(7)

The average engine is defined as the average of all the certification compliant engines used during the airplane flight tests, up to and during certification, when operating within the limitations and according to the procedures given in the Flight Manual. This will determine the relationship of thrust/power to control parameters (e.g., N_1 or EPR). Noise measurements made during certification tests must be corrected using this relationship.

a. Explanation

This Section specifies criteria for defining an airplane's average engine thrust (power) characteristics.

c. Procedure

- (1) Applicant's Responsibility: An applicant must define and obtain FAA approval of an airplane's average engine thrust (power) characteristics to calculate reference EPNL values.

315. Section B36.7(c) Approach reference procedure:

The approach reference flight path must be calculated using the following:

316. Section B36.7(c)(1)

The airplane is stabilized and following a 3° glide path;

a. Explanation

This Section specifies the reference conditions that an applicant must use in calculating an approach reference flight path.

317. Section B36.7(c)(2)

For subsonic airplanes, a steady approach speed of $V_{REF} + 10$ kts ($V_{REF} + 19$ km/h) with thrust and power stabilized must be established and maintained over the approach measuring point. For Concorde airplanes, a steady approach speed that is either the landing reference speed + 10 knots or the speed used in establishing the approved landing distance under the airworthiness regulations constituting the type certification basis of the airplane, whichever speed is greater. This speed must be established and maintained over the approach measuring point.

a. Explanation

This Section specifies the criteria that an applicant must use to determine reference approach airspeeds for subsonic airplanes.

318. Section B36.7(c)(3)

The constant approach configuration used in the airworthiness certification tests, but with the landing gear down, must be maintained throughout the approach reference procedure;

b. Supplemental Information

- (1) Approach Airworthiness Certification: Airplanes are frequently airworthiness certificated for more than one approach configuration that may include:

- Multiple approach/landing flap settings and landing weights
- In-flight operable APU,
- Environmental Control system operational conditions,
- Engine bleed valve operational conditions.

The configuration that is most critical from a noise standpoint is the configuration that must be used for determination of reference approach EPNL values.

- (2) Emergency Approach Configuration: Some airplanes are equipped with emergency in-flight operable equipment such as emergency air-turbine driven generators and emergency air-turbine driven hydraulic pumps. Emergency equipment operation is not a part of normal approach airworthiness approved configurations that require part 36 compliance.

- (3) Restricted Configurations: On some airplanes, flap settings must be restricted in order to comply with Part 36 maximum noise levels (See section B36.5). For Stage 3 airplanes that require a flap restriction in order to comply with part 36, soft-guards and appropriate placards are required to be installed. Soft-guards make it obvious that flap settings that are greater than the restricted flap setting are not to be used

for normal operation, and would indicate any use of the unapproved settings by deformation of the softguard. Softguards also permit extended (greater) flap settings to be used for declared emergency conditions for safety purposes at the discretion of the flight crew.

c. Procedure

- (1) Applicant's Responsibility: The applicant is responsible for demonstrating that an appropriate airplane configuration is selected and maintained in determining a noise certification approach reference procedure. This includes evaluating which approach configuration is most critical for approach noise certification and identifying that critical configuration in a noise certification compliance demonstration plan.

319. Section B36.7(c)(4)

The weight of the airplane at touchdown must be the maximum landing weight permitted in the approach configuration defined in paragraph (c)(3) of this section at which noise certification is requested, except as provided in § 36.1581(d) of this part; and

a. Explanation

This section specifies criteria for defining the reference maximum landing weight of an airplane for noise certification.

320. Section B36.7(c)(5)

The most critical configuration must be used; this configuration is defined as that which produces the highest noise level with normal deployment of aerodynamic control surfaces including lift and drag producing devices, at the weight at which certification is requested. This configuration includes all those items listed in section A36.5.2.5 of appendix A of this part that contribute to the noisiest continuous state at the maximum landing weight in normal operation.

a. Explanation

This section specifies criteria for defining the reference configuration of an airplane for noise certification.

b. Procedures

- (1) Most Critical Approach Configuration: An applicant must determine the most noise critical configuration at the airplane's maximum landing weight by evaluation of appropriate measured noise data and/or experience, or similarity with other airplane models. The results of this evaluation must include the effects of items listed in Section B36.5.2.5.

Note: Example items warranting consideration are as follows:

- Flaps extended to the extreme approved landing flap position (e.g., 30° flaps) for turbojet airplanes and to the least approved landing flap position (e. g. 10° flaps) for turbo-propeller airplanes
- A/C (Environmental Control System) operating;
- Landing gear extended;
- Operation of an APU in-flight;
- Maximum approved landing gross weight, and
- Inter-compressor bleed trimmed to maximum trim stop.

321. Section B36.8 Test procedures322. Section B36.8(a)

All test procedures must be approved by the FAA.

a. Explanation

This section specifies a requirement for FAA approval of an applicant's proposals for airplane noise certification test procedures and noise measurements.

c. Procedures

- (1) FAA Responsibilities: A FAA observer, or appropriate designee, that ensures compliance with an approved Type Inspection Authorization, must witness airplane noise certification tests.
- (2) Test Records: Test records, such as those required by a Type Inspection Authorization (TIA) are to be prepared by the FAA and stored as a part of the compliance records. An applicant may assist the FAA with the development of these records. See Chapter 2, paragraph 16, of FAA Order 8110.4A (Ref. 3.a) for additional information.
- (3) Constant Configuration: A flight crew must not to modify the takeoff or approach configurations during noise certification testing. They should set the airplane configuration (including engine thrust (power), flap position, APU and A/C operation, gear position, etc.) in sufficient time to stabilize all conditions prior to the initial 10 dB-down point, and maintain that configuration constant until after the final 10 dB-down point.

Note: throttle movement during the noise measurement is not permitted, except as required by the pilot-in-command to ensure safety. If this occurs, the noise level certification test condition is invalid, and is repeated.

323. Section B36.8(b)

The test procedures and noise measurements must be conducted and processed in an approved manner to yield the noise evaluation metric EPNL, in units of EPNdB, as described in appendix A of this part.

324. Section B36.8(c)

Acoustic data must be adjusted to the reference conditions specified in this appendix using the methods described in appendix A of this part. Adjustments for speed and thrust must be made as described in section A36.9 of this part.

325. Section B36.8 (d)

If the airplane's weight during the test is different from the weight at which noise certification is requested, the required EPNL adjustment may not exceed 2 EPNdB for each takeoff and 1 EPNdB for each approach. Data approved by the FAA must be used to determine the variation of EPNL with weight for both takeoff and approach test conditions. The necessary EPNL adjustment for variations in approach flight path from the reference flight path must not exceed 2 EPNdB.

a. Explanation

This section specifies limits on EPNL adjustments due to differences between takeoff and approach test weight and the maximum weight at which noise certification is requested.

b. Supplemental Information

- (1) Equivalent Procedure: The requirements of Section B36.8 (d) do not apply when approved equivalent noise measurement and evaluation procedures are used to develop Noise-Power-Distance (NPD) data for airplane noise certification compliance. (See Section 2.1.2 of the appended ICAO TM).

c. Procedures

- (1) Applicants Responsibility: The applicant is responsible to obtain approval of equivalent noise measurement and evaluation procedures or substantiate that EPNL adjustments due to differences between test weights and maximum weights at which noise certification is requested do not exceed 2 EPNdB.

326. Section B36.8 (e)

For approach, a steady glide path angle of $3^\circ \pm 0.5^\circ$ is acceptable.

a. Explanation

This Section specifies limits on airplane deviations from a 3° glide path during approach noise certification measurements.

b. Supplemental Information

- (1) Equivalent Procedure: The requirements of B36.8 (e) regarding limits on glide path deviations do not apply when approved equivalent noise measurement and evaluation procedures are used to develop Noise-Power- Distance (NPD) data for airplane noise certification compliance (See Sections 2.1.2, 2.1.1.3, and 2.1.1.4 of the appended ICAO TM).

c. Procedures

- (1) Applicant's Responsibility: The applicant is responsible to obtain approval for equivalent noise measurement and evaluation procedures or ensure that approach tests are conducted within the specified glide path tolerances.

327. Section B36.8 (f)

If equivalent test procedures different from the reference procedures are used, the test procedures and all methods for adjusting the results to the reference procedures must be approved by the FAA. The adjustments may not exceed 16 EPNdB on takeoff and 8 EPNdB on approach. If the adjustment is more than 8 EPNdB on takeoff, or more than 4 EPNdB on approach, the resulting numbers must be more than 2 EPNdB below the limit noise levels specified in section B36.5.

c. Procedures

- (1) Integrated Method: An applicant must use the “integrated method”, specified in Section A36.9.4, when approved equivalent noise measurement and evaluation procedures result in EPNdB adjustments more than 8 EPNdB for takeoff and 4 EPNdB for approach (See requirements specified in section A36.9.1.2).

328. Section B36.8 (g)

During takeoff, lateral, and approach tests, the airplane variation in instantaneous indicated airspeed must be maintained within +/-3% of the average airspeed between the 10dB-down points. This airspeed is determined by the pilot's airspeed indicator. However, if the instantaneous indicated airspeed exceeds +/-3 kt (+/-5.5 km/h) of the average airspeed over the 10dB-down points, and is determined by the FAA representative on the flight deck to be due to atmospheric turbulence, then the flight so affected must be rejected for noise certification purposes.

Note. Guidance material on the use of equivalent procedures is provided in the current Advisory Circular for this part.

b. Supplemental Information

- (1) Airspeed Variations: Possible causes and potential effects of airspeed variations during noise certification measurements are discussed under section A36.2.2.2 (f) of this AC.

329. - 349. [RESERVED]